Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

SHOUT
SHARE
IT

En 82B

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 66.
L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

LIBRARY
RECEIVED
OCT 21 1910
U. S. Department of Agriculture

I. THE ASPARAGUS MINER.
NOTES ON THE ASPARAGUS BEETLES.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

II. THE WATER-CRESS SOWBUG.
THE WATER-CRESS LEAF-BEETLE.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

III. THE CRANBERRY SPANWORM.
THE STRIPED GARDEN CATERPILLAR.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

IV. THE LEAFHOPPERS OF THE SUGAR BEET AND THEIR RELATION TO THE "CURLY-LEAF" CONDITION.
By E. D. BALL, Ph. D., *Special Field Agent.*

V. THE SEMITROPICAL ARMY WORM.
By F. H. CHITTENDEN and H. M. RUSSELL.

VI. THE HOP FLEA-BEETLE.
By F. H. CHITTENDEN, Sc. D., *in Charge of Truck Crop and Special Insect Investigations.*

VII. MISCELLANEOUS NOTES ON TRUCK-CROP INSECTS
By F. H. CHITTENDEN, Sc. D., *in Charge of Truck Crop and Stored Product Insect Investigations.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 66.
L. O. HOWARD, Entomologist and Chief of Bureau.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

I. THE ASPARAGUS MINER.
NOTES ON THE ASPARAGUS BEETLES.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

II. THE WATER-CRESS SOWBUG.
THE WATER-CRESS LEAF-BEETLE.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

III. THE CRANBERRY SPANWORM.
THE STRIPED GARDEN CATERPILLAR.
By F. H. CHITTENDEN, *Entomologist in Charge of Breeding Experiments.*

IV. THE LEAFHOPPERS OF THE SUGAR BEET AND THEIR RELATION TO THE "CURLY-LEAF" CONDITION.
By E. D. BALL, Ph. D., *Special Field Agent.*

V. THE SEMITROPICAL ARMY WORM.
By F. H. CHITTENDEN and H. M. RUSSELL.

VI. THE HOP FLEA-BEETLE.
By F. H. CHITTENDEN, Sc. D., *in Charge of Truck Crop and Special Insect Investigations.*

VII. MISCELLANEOUS NOTES ON TRUCK-CROP INSECTS.
By F. H. CHITTENDEN, Sc. D., *in Charge of Truck Crop and Stored Product Insect Investigations*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1910.

BUREAU OF ENTOMOLOGY.

L. O. Howard, *Entomologist and Chief of Bureau.*

C. L. Marlatt, *Assistant Entomologist and Acting Chief in Absence of Chief.*

R. S. Clifton, *Executive Assistant.*

Chas. J. Gilliss, *Chief Clerk.*

F. H. Chittenden, *in charge of truck crop and stored product insect investigations.*
A. D. Hopkins, *in charge of forest insect investigations.*
W. D. Hunter, *in charge of southern field crop insect investigations.*
F. M. Webster, *in charge of cereal and forage insect investigations.*
A. L. Quaintance, *in charge of deciduous fruit insect investigations.*
E. F. Phillips, *in charge of bee culture.*
D. M. Rogers, *in charge of preventing spread of moths, field work.*
Rolla P. Currie, *in charge of editorial work.*
Mabel Colcord, *librarian.*

Truck-Crop and Stored Product Insect Investigations.

F. H. Chittenden, *in charge.*

H. M. Russell, C. H. Popenoe, D. K. McMillan, H. O. Marsh, E. G. Smyth, Thos. H. Jones, *agents and experts.*
E. D. Ball,[a] *special field agent.*
E. G. Titus,[a] I. J. Condit, H. S. Heller,[b] W. B. Parker, *collaborators.*

---

[a] Resigned June 30, 1909. [b] Resigned January 31, 1910.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., January 25, 1910.

Sir: I have the honor to transmit herewith, for publication as Bulletin No. 66, seven papers dealing with certain insects injurious to truck crops. These papers, which were issued separately during the years 1907 and 1909, are as follows: The Asparagus Miner and Notes on the Asparagus Beetles, by F. H. Chittenden; The Water-Cress Sowbug and the Water-Cress Leaf-Beetle, by F. H. Chittenden; The Cranberry Spanworm and the Striped Garden Caterpillar, by F. H. Chittenden; The Leafhoppers of the Sugar Beet and Their Relation to the "Curly-Leaf" Condition, by E. D. Ball; The Semi-tropical Army Worm, by F. H. Chittenden and H. M. Russell; The Hop Flea-Beetle, by F. H. Chittenden; Miscellaneous Notes on Truck-Crop Insects, by F. H. Chittenden.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The present publication comprises a series of articles which have been issued in seven parts and are now brought together as a single bulletin. It relates to a line of investigations begun in 1896, the earlier results of which were published in previous bulletins of the present series, in Yearbooks of the Department, and in circulars of the Bureau. The title, "Some Insects Injurious to Truck Crops," is used in a wide sense and includes insects injurious to sugar beet, since the same class of insects which affect this important crop also attack table beets and spinach.

The initial article is the first treatment that has been given to the asparagus miner in a Government publication. The second article, entitled "Notes on the asparagus beetles," is a sequel to a general article on the asparagus beetles which appeared in the Yearbook for 1896. It places on record all important new localities to date, and furnishes similarly the latest information in regard to remedies. The importance which has been assumed by the water-cress sowbug since 1902 has necessitated the preparation of a publication covering this species, with suggestions for its control. The subject of water-cress insects has never been considered in a Department publication hitherto, and similar treatment of the water-cress leaf-beetle to that furnished on the sowbug follows. The cranberry spanworm is given monographic treatment not hitherto furnished for it. It is an omnivorous feeder, and has attracted attention on various crops, and especially on asparagus and strawberry. A similar article on the striped garden caterpillar, also an omnivorous form, completes Part III of the bulletin.

The article representing Part IV is a detailed consideration of the sugar-beet leafhopper and of other affiliated species in their relation to the "curly-leaf" condition of the sugar beet. It was prepared by Dr. E. D. Ball while special field agent of this Bureau in Utah; he has been engaged on this work for a number of years. The semitropical army worm is the subject of Part V. It was the most troublesome insect on truck crops in Florida during 1907, and was given detailed study from every possible standpoint by the authors. In the experiments with remedies, which were conducted by the junior author, Mr. H. M. Russell, a series of 15 trials was performed, proving that a spray of arsenate of lead is far superior to Paris green under local

conditions. The final article of the series, entitled "The hop flea-beetle," has been a subject of study for a number of years. Its treatment is monographic to date, and, while some of the data furnished are preliminary in character, it will constitute a basis for future work on the same species. This insect is given the name of flea-beetle because of the local name, "hop flea," used in the hop-growing region of the Pacific coast, but it is also a pest in sugar-beet fields and in urious to rhubarb, radishes, and other truck crops. In the preparation of the article the writer has been fortunate in obtaining the cooperation of various experts, including, particularly, Messrs. H. J. Quayle and Theodor Eder.

Following this article are a few miscellaneous notes on truck-crop insects, the first two giving additional information in regard to the principal asparagus pests treated in Part I, the last furnishing additional observations on the water-cress insects treated in Part II, with notes on the first injurious occurrence of the destructive pea moth and of a western root-maggot in the United States.

F. H. Chittenden.

CONTENTS.[a]

		Page.
The asparagus miner (*Agromyza simplex* Loew)	*F. H. Chittenden*	1
Descriptive		1
Distribution		2
Historical and biological notes		2
Recent injury		3
Remedial measures		4
Notes on the asparagus beetles	*F. H. Chittenden*	6
The common asparagus beetle (*Crioceris asparagi* L.)		6
The twelve-spotted asparagus beetle (*Crioceris 12-punctata* L.)		9
The water-cress sowbug (*Mancasellus brachyurus* Harger)	*F. H. Chittenden*	11
Descriptive		11
Reports of injurious occurrence		12
Methods of control		12
The water-cress leaf-beetle (*Phædon æruginosa* Suffr.)	*F. H. Chittenden*	16
Injurious occurrence		16
Descriptive		16
Literature		18
Habits of this and a related species		18
Methods of control		19
The cranberry spanworm (*Cleora pampinaria* Guen.)	*F. H. Chittenden*	21
Descriptive		21
Distribution		23
Biologic literature		24
Unpublished office notes		25
List of food plants		25
The insect's life history		26
Natural enemies		26
Remedies		26
Bibliography		27
The striped garden caterpillar (*Mamestra legitima* Grote)	*F. H. Chittenden*	28
Descriptive		28
Biologic notes		29
Natural enemies		31
Summary of habits		32
Methods of control		32
The leafhoppers of the sugar beet and their relation to the "curly-leaf" condition	*E. D. Ball*	33
Introduction		33
The beet leafhopper (*Eutettix tenella* Baker)		35
Descriptive		35
Food plants		35
Distribution		36
Life-history studies		36
Economic relations		41
Economic summary and proposed remedies		47
Bibliographical references		48

[a] The seven papers constituting this bulletin were issued in separate form on March 16, April 23, and August 31, 1907, and on January 27, January 28, May 8, and July 19, 1909, respectively.

The leafhoppers of the sugar beet and their relation to the "curly-leaf" condition—Continued. Page.
Other leafhoppers 49
Eutettix strobi Fitch 49
Eutettix scitula Ball 49
Eutettix seminuda Say 50
Eutettix clarivida Van Duzee 50
Eutettix insana Ball, *E. albida* Ball, and *E. pauperculata* Ball 50
Eutettix stricta Ball 50
Agallia sanguinolenta Prov 51
Agallia cinerea Osborn and Ball 51
Agallia bigeloviæ Baker 51
Agallia quadripunctata Prov. and *A. novella* Say 51
Empoasca sp 51
Conclusions in regard to "curly-leaf" 52
The semitropical army worm (*Prodenia eridania* Cram.).
F. H. Chittenden and H. M. Russell 53
Introduction 53
Descriptive 54
Origin and distribution 57
Literature and history 57
Recent injuries and biologic notes 58
Early records 62
Life-cycle periods and generations 62
Natural enemies 63
Methods of control 65
Résumé of experiments and conclusions 68
Summary 69
Bibliographical list 70
The hop flea-beetle (*Psylliodes punctulata* Melsh.) *F. H. Chittenden* 71
Introductory 71
Descriptive 72
Distribution 73
Recent injuries 73
Methods of attack, food habits, and generations 76
Life history and habits 79
Notes on other species 81
Local conditions and natural influences 82
Methods of control 83
Arsenicals 83
Contact sprays 85
Bordeaux mixture 87
Mechanical and cultural methods 87
Literature 91
Bibliography 91
Summary 92
Miscellaneous notes on truck crop insects *F. H. Chittenden* 93
Successful use of arsenate of lead against the asparagus beetle 93
A note on the asparagus miner 94
Injurious occurrence of the pea moth in the United States 95
A new western root-maggot 95
Notes on water-cress insects 96
Index 99

ILLUSTRATIONS.

PLATES.

Page.

PLATE I. Leafhoppers (*Eutettix* spp.) and their work. Fig. 1.—*Eutettix tenella:* *a*, Adult; *b*, nymph; *c*, wing; *d*, *e*, genitalia; *f*, eggs (greatly enlarged); *g*, section of beet stem, showing fresh eggs in place; *h*, same, showing eggs ready to hatch; *i*, old egg scars on beet stems; *j*, small leaf of sugar beet, showing characteristic "curly-leaf" condition; *k*, enlarged section of back of an extreme case of "curly-leaf," showing "warty" condition of veins. Fig. 2.—*Eutettix strobi:* *a*, Work of nymphs on lamb's-quarters; *b*, work of nymphs on sugar beet. Fig. 3.—*Eutettix scitula:* Adult. Fig. 4.—*Eutettix clarivida:* *a*, Wing; *b*, head and pronotum; *c*, *d*, genitalia. Fig. 5.—*Eutettix nigridorsum:* Work of nymphs on leaf of Helianthus. Fig. 6.—*Eutettix straminea:* Work of nymphs on leaf of another Helianthus. Fig. 7.—*Eutettix insana:* Wing. Fig. 8.—*Eutettix stricta:* *a*, *b*, Genitalia 34

II. Work of *Eutettix tenella* on sugar beet. Fig. 1.—Three "curly-leaf" beets, the result of attack by *Eutettix tenella*, and one normal beet from the same field, showing difference in size. Figs. 2, 3.—"Curly-leaf" beets as seen in the field. Fig. 4.—Normal beets from same field 44

III. Work of *Eutettix tenella* on sugar beet. Fig. 1.—A large beet becoming "curly." Fig. 2.—Back of a leaf affected by "curly-leaf," showing "warty" condition and curled edges 44

IV. Work of *Eutettix tenella* on sugar beet. Fig. 1.—A field of beets destroyed by "curly-leaf." Figs. 2, 3.—Cages used in the life-history experiments 46

V. Spraying apparatus used in hopyards in British Columbia 84

VI. View of hopyard, showing sheep keeping down weeds 88

VII. Method of capturing hop flea-beetles on tarred horse-sledges 90

TEXT FIGURES.

FIG. 1. The asparagus miner (*Agromyza simplex*): Fly 1

2. The asparagus miner: Larva, pupa, work 2

3. The water-cress sowbug (*Mancasellus brachyurus*) 12

4. Cross section of cress pond, showing arrangement for avoiding damage by water-cress sowbug 13

5. The water-cress leaf-beetle (*Phædon æruginosa*): Larva, pupa, adult 17

6. The cranberry spanworm (*Cleora pampinaria*): Moth, larva, and pupa 22

7. The striped garden caterpillar (*Mamestra legitima*): Moth, larva, and pupa 29

8. The semitropical army worm (*Prodenia eridania*): Moth, egg, egg-mass, larvæ 54

Page.

FIG. 9. The semitropical army worm: Work of larvæ on "careless weed" in potato field 59
10. The semitropical army worm: Field of late Irish potatoes, showing vines entirely stripped by larvæ 60
11. The semitropical army worm: Larvæ eating bark of "careless weed;" also nymph of spined soldier-bug (*Podisus maculiventris*), predaceous on larvæ of *Prodenia eridania* 61
12. Hop flea-beetle (*Psylliodes punctulata*): Larva and adult 72
13. View of hopyard, showing how flea-beetles keep down vines 76
14. Hop leaves, showing work of flea-beetle 77
15. Work of flea-beetle after vines are grown 78
16. Trained hop shoots stripped by flea-beetle 79
17. Breeding and control cage in place over a hill 80
18. A crew spraying hops in British Columbia 86
19. Tarred catchers for hop flea-beetles 89

U. S. D. A., B. E. Bul. 66, Part I. Issued March 16, 1907.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE ASPARAGUS MINER.

(*Agromyza simplex* Loew.)

By F. H. Chittenden,

Entomologist in Charge of Breeding Experiments.

The stalks of asparagus are frequently attacked by insects, and in recent years have been reported considerably injured by the larva or maggot of a minute black fly to which the name asparagus miner has been given. The larva mines under the epidermis of the stalk, and when it has transformed to the puparium or "flaxseed" stage the thin outer skin becomes more or less ruptured and the presence of the insect is easily detected. It operates more abundantly near the base of the stalks and penetrates below the surface of the ground to a depth of 7 or 8 inches. During the year 1906 this species attracted considerable attention by its abundance in some of the principal asparagus-growing sections of New England and it bids fair to become a pest of considerable importance. It was first noticed on asparagus

Fig. 1.—*Agromyza simplex:* Fly, dorsal view at left, lateral view at right. Highly magnified (original).

in 1896, ten years earlier than the present writing, prior to which time nothing was known of its habits. It is a native species and evidently restricted to asparagus as a food plant. Until the year 1906 it had not been recognized as doing injury to cutting beds, although attack had been observed in various sections. The mines of the larvæ about and below the bases of the stalks are frequently so abundant that they have the effect of girdling, so that the injured stalks can be readily pulled from the ground.

DESCRIPTIVE.

The parent insect is a two-winged fly (fig. 1), metallic black, with large prominent head and eyes, and clear wings, the wing expanse being about one-sixth of an inch (4 mm.).

The larva (fig. 2, *a*) is about one-fifth of an inch long and milk-white in color. Like other maggots, it is footless, large at the posterior extremity, and tapering toward the head.

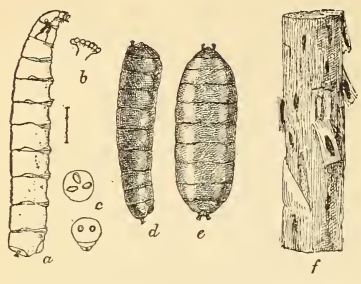


FIG. 2.—*Agromyza simplex: a*, larva, lateral view; *b*, thoracic spiracles; *c*, anal spiracles; *d*, puparium from side; *e*, same from above; *f*, section of asparagus stalk, showing injury and location of puparia on detached section; *a-e*, much enlarged; *f*, slightly reduced (original).

The puparium (fig. 2, *d*, *e*) is not unlike the "flaxseed" of the pernicious Hessian fly, with which it has been aptly compared. At a little distance, also, it suggests a Lecanium scale. This stage is remarkable because of its peculiar flattened and curved position, as seen from the side. It is red in color, and measures about 3.5 mm. in length and about 1 mm. in width.

The egg has not been observed.

This species belongs to the dipterous family Agromyzidæ, and was described by Loew in 1869,[a] the locality being given as "Middle States."

DISTRIBUTION.

In its injurious occurrences this species appears to be limited to the eastern United States, from New England to Tennessee. From available data it is quite obvious, however, that it may be destructive over a considerable territory, including a large portion of Massachusetts and Connecticut, Long Island, the District of Columbia, Pennsylvania, and Tennessee. As it is recorded from New Jersey, it is probably injurious there, although no reports of injury in that State have reached this office. In time it will doubtless attract attention in intermediate points and in States farther north and west. It has also appeared in asparagus beds in California.

HISTORICAL AND BIOLOGICAL NOTES.

In May, 1897, and afterwards this fly was observed in abundance by the writer on terminal shoots of asparagus, particularly at Cabin John, Md. Two weeks later no more flies were seen, but June 26 they reappeared and were then usually seen *in copula*. It was surmised at the time that this second appearance indicated the first new generation of the year and its abundance on asparagus seemed to show that it lived in some manner at the expense of that plant. Examination of asparagus plants at that time, however, failed to show attack. The facts which have just been narrated were published in 1898.[b]

---

[a] Diptera Americæ septentrionalis indigena, Centuria octava 84, p. 46.

[b] Bul. 10, n. s., Div. Ent., U. S. Dept. Agric., p. 62, 1898.

In 1900 we received complaint of injuries in the District of Columbia, and from Knoxville, Tenn., and in the meantime the species came under the observation of Mr. F. A. Sirrine, who has stated[a] that work was first observed in asparagus fields on Long Island in 1896. This statement is made in a bulletin of six pages, which represents all that was known of the species at that time.

Late in September, 1900, word was received from Mr. Frederic Voigt, Tennallytown, D. C., of injury to the stalks of asparagus on his and a neighboring truck farm. When the writer visited the field, however, although injury was apparent on the outer skin of some stalks, no living specimens could be obtained, only the dried puparia being in evidence at this time. October 2 of the same year, Mr. Samuel M. Bain, University of Tennessee, Knoxville, Tenn., sent a stalk of asparagus showing the work of this miner upon the skin, and, October 27, specimens of the dried puparia.

February 18, 1901, Mr. T. Miles Brous, Bustleton, Philadelphia, Pa., wrote that this insect, which he accurately described, seemed to cause much greater trouble than the common asparagus beetle. A neighbor had lost two or three new beds of asparagus on account of its ravages.

By the writer's direction, Mr. F. C. Pratt visited a large truck farm at Brookland, D. C., where asparagus was one of the main crops, June 18, 1902. Asparagus was still being cut for market, but volunteer plants were growing here and there in fields of corn, cantaloupe, and potatoes, between rows. A few flies were seen on terminal shoots of asparagus that showed wilting, and many volunteer plants were found badly infested, most individuals having transformed to pupæ. Although stems break off just below the ground, the entire colony of insects below that point is left with sufficient moisture and nourishment for their maintenance. The puparia were present in great numbers underneath the outer skin of the root, and as many as nine puparia were counted in a space only an inch long on one stalk. The stalks below the point of injury appeared to be perfectly sound. Larvæ also were found in rotting stalks that broke off just below ground.

During 1905 Mr. Ralph E. Smith reported this species as becoming abundant in California, though not of any great importance at that time. His description of the insects' manner of work leaves no doubt as to the identity of the species.[b]

RECENT INJURY.

During September, 1906, Messrs. J. B. Norton and A. D. Shamel, of the Bureau of Plant Industry, furnished stems of asparagus from Concord, Mass., showing severe infestation by this species, many

[a] Bul. 189, N. Y. Agric. Exp. Sta., p. 277, Geneva, 1900.

[b] Bul. 165, Univ. of Cal. Agric. Exp. Sta., p. 96, 1905.

puparia being present under the mined outer skin. In the neighborhood of Concord, a very important asparagus-growing region where hundreds of acres are devoted to this crop, the infestation was practically absolute, the insect being found even as abundantly as the common asparagus beetle, being present wherever rust was found, as also where no rust was present. The specimens submitted were about the average as regards the degree of infestation, some plants showing injury 7 inches below the surface.

Severe injury was reported on the farms of Mr. Frank Wheeler and Mr. Charles W. Prescott, at Concord, Mass. The growers in that region had never noticed this insect until Mr. Shamel's examination showed that its injuries were extensive. Later Mr. Shamel reported finding infestation in every field and patch of asparagus which he visited in Massachusetts and Connecticut, particularly at Suffield, Granby, and Hartford, Conn., and he believed attack to be widespread.

October 26, 1906, Mr. Ralph E. Smith wrote, by request, that the conditions under which this asparagus miner was found in abundance in the yellow stalks of asparagus in California, as reported by him in an article on Asparagus Rust Control,[a] had prevailed for two or three years. The insect was always very abundant at the base of these yellow, dying stalks, although the injury was attributed to the "centipede," reported as wireworms on a previous occasion.[b]

REMEDIAL MEASURES.

Witn our present knowledge of the life economy of this species, two methods of control suggest themselves as of greatest value, and it may be that they will prove all that is necessary under ordinary conditions.

(1) In spring permit a few volunteer asparagus plants to grow as a trap crop, to lure the fly from the main crop or the cutting beds for the deposition of her eggs. After this has been accomplished the trap crop should be destroyed by pulling the infested plants and burning them with their contained puparia. The time to pull the plants will vary according to locality and somewhat according to season also. The second and third week in June would be about the right time in and near the District of Columbia. On Long Island this work should be done a week or two later. In the northernmost range of this insect—for example, in Massachusetts—the last of June and the first of July would probably be a suitable time.

(2) The second generation can be destroyed in like manner by pulling old infested asparagus stalks as soon as attack becomes manifest and promptly burning them also.

---

[a] Bul. 172, Univ. Cal. Agric. Exp. Sta., p. 21; [b] Bul. 165, l. c.

If this work were carefully done over a considerable area, it would leave little necessity for other methods, since it would do away with these insects in the vicinity and leave few to be dealt with another season; unless, indeed, this insect has an alternate food plant. The cooperation of neighboring asparagus growers and thoroughness are essential for success.

This method will operate also against the rust which is now present in many fields infested by the miner.

NOTES ON THE ASPARAGUS BEETLES.

By F. H. Chittenden,
Entomologist in Charge of Breeding Experiments.

Since the publication of the writer's general article on the asparagus beetles in the Yearbook for 1896,[a] many notes on their distribution and destructive occurrences have been published. Some additional data were published soon afterward.[b] The following brief review of the subject is submitted as a sequel to those articles and a summary of the further dissemination of these pests in a decade of years.

THE COMMON ASPARAGUS BEETLE.

(*Crioceris asparagi* L.)

The predictions made by the writer in regard to the future distribution of the common asparagus beetle have been completely fulfilled as regards its western spread, although it has not as yet been reported as far south as Kentucky. Mr. J. G. Sanders, however, informs the writer that it has been established about Columbus, Ohio, since 1903, and Mr. Charles Dury, Cincinnati, Ohio, reported this species at Indian Hill, about 7 miles from that city, on asparagus beds in 1905. Hundreds were observed during June. The customary injury was noticed, and plants appeared as though scorched with fire. In 1897 the species was observed to have continued its spread westward along Lake Erie, and was then known in nine counties in northeastern Ohio. The following year it was first noticed in western Virginia. In 1898 also it was reported to have been present at Benton Harbor, Mich., since 1896. By 1899 it had made its appearance in Canada, accompanied by the twelve-spotted species, in the Niagara River region.

It is interesting to note that in 1900 the present species, which had been rapidly increasing its range in the East, including New York, after occurring in injurious numbers in Maryland, was apparently totally destroyed by the hot spell of July and August that occurred in the District of Columbia and neighboring parts of Virginia and Maryland; whence the conclusion that this condition prevailed to a considerably larger extent than came to the writer's personal notice. In 1901 Dr. James Fletcher noted that the species, though present in the Niagara district, had not increased to the extent that was feared. It had spread to Guelph, Ontario, that year, and did much damage about St. Catharines. In 1904 its occurrence around Toronto was

[a] Yearbook U. S. Dept. Agric. f. 1896 (1897), pp. 341–352.

[b] Bul. 10, n. s., Div. Ent., U. S. Dept. Agric., pp. 54–59, 1898.

noticed. It was reported also 40 miles west of Chicago, Ill. It has become very generally distributed in asparagus-growing districts in New York State, and has reached Glens Falls, which approximates its northernmost limit in this country. In 1905 we received complaint of this insect as a pest in Illinois, at Park Ridge, and of its occurrence about Chicago. Reports from Michigan showed that it had been present there in 1904 in the vicinity of Ada, about 10 miles from Grand Rapids, and that it was a pest in that vicinity.

Although the data given above indicate that the species is now well distributed throughout the Upper Austral region, for some reason its occurrence in Indiana has not yet come to our knowledge; nevertheless although there are naturally many uninvaded localities, it is undoubtedly established in that State, most probably near Lake Michigan.

As an example of its manner of distribution, it might be noted that in May, 1905, the beetle was found for the first time in Warrenton, Fauquier County, Va., a little farther inland than it had ever been noticed in that section. Yet this species has been permanently established in the adjoining Alexandria County for many years.

August 8, 1905, Mr. Ralph E. Smith wrote of the occurrence of this species in California, stating that during two seasons it had been very abundant at Bouldin Island, the principal asparagus center of that region. As Mr. Smith was familiar with this insect and its occurrence on the Atlantic coast, there is little doubt that his identification is correct. In the winter of 1904 to 1905 Bouldin Island was flooded and remained under water for over a year. It had just been reclaimed and there were no signs of the beetles. There is, therefore, a possibility that the insect was exterminated in that region, and this includes the State, if the occurrence of the species was only local.

The dying out of this asparagus beetle in small localities where it has not become thoroughly established is not without precedent, as its recorded occurrence at Rock Island, Ill., many years ago, has been verified by specimens now in a Chicago museum, properly labeled as collected there by the late A. Bolter, an experienced collector of Coleoptera. Indeed, it would seem that few vegetable-feeding insects are more subject to extermination in a limited locality not contiguous to one also infested than is the present species.

October 26, 1906, Mr. Ralph E. Smith, at the writer's request, reported the status of this species in California. He wrote that during the summer he found the beetles again, and that they were very abundant in fields near Oakley, Cal. It could not be stated that the insect was of general occurrence in the State, but apparently it existed only in a few scattered colonies. As previously reported the colony at Bouldin Island appears to have been exterminated by flood, and

the Oakley occurrence was the first that Mr. Smith had noted since. In most of the asparagus acreage of the State the insect was not yet present.

Mr. Franklin Sherman, jr., has kept a careful record of the occurrence of this species in North Carolina, and informed the writer, on the occasion of a visit in 1906, that it is common in the east-central part of the State in the trucking belt, and especially abundant at Raleigh, Wake County, Goldsboro, Wayne County, and Warsaw, Duplin County.

In order to make the present account of the known distribution of this species as complete as possible, inquiry was made of the official entomologists of the States of Kentucky, Iowa, Missouri, Nebraska, and Minnesota, all of whom reported that the occurrence of this species in their States had not been brought to their attention. Mr. James G. Moore, however, assistant in horticulture at the University of Wisconsin, Madison, Wis., stated that the asparagus beetle had been found in Wisconsin, but he had no special data on its distribution.

REMEDIES.

With regard to remedies good results have followed the experimental use of arsenate of lead. This insecticide has come into very general favor in recent years, and in the correspondence of this office we have for some time advised its employment against most leaf-feeding beetles, like the asparagus beetles. In Connecticut Dr. W. E. Britton [a] has made a practical test of this remedy on asparagus plants, spraying them from all four sides in succession because of the slight leaf exposure as compared with most other plants. The day following treatment (June 4) many dead beetles and larvæ were found on and under the plants. A few had survived and were feeding, but ten days later only a few living larvæ could be found, and the beetles did not again become abundant on the plants during the summer. The same amount of good might be accomplished with scarcely greater expense by spraying from opposite sides and repeating just before the time for the last generation to develop and in time to check the beetles before they go into winter quarters.

In Pennsylvania Prof. H. A. Surface,[b] in a series of experiments with Paris green and arsenate of lead, applied to asparagus plants the first week of June, 1905, found that not more than 50 per cent of the insects were killed when Paris green and lime were used. With lead arsenate 90 per cent were killed, while in one experiment, by the addition of resin soap, which is used as an addition to an insecticide to

[a] Rept. Conn. Agric. Exp. Sta. f. 1903 (1904), pp. 275, 276.

[b] Monthly Bulletin, Div. of Zool., Pa. State Dept. Agric., Vol. IV, May, 1906, p. 8.

enable the poison to adhere better to smooth plants, 100 per cent of the insects were killed on the 50 plants treated. In this case the arsenate of lead was used at the rate of about 1 pound to 24 gallons of water, and 2½ pounds of soap were added.

Arsenate of lead has been used with satisfactory results on asparagus at the rate of 1 pound in 16 to 24 gallons of water. Additional experiments are necessary to ascertain the exact amount of the poison that can be used economically to produce the best effect. In Professor Surface's experiments evidently only a single spray was applied.

THE TWELVE-SPOTTED ASPARAGUS BEETLE.

(*Crioceris 12-punctata* L.)

Nearly every year since 1896, when the distribution of the twelve-spotted asparagus beetle was recorded by the writer,[a] the appearance of this species has been noted in new localities in the United States, until it is now well distributed westward and especially northward.

In 1898 Dr. J. B. Smith stated that it then occurred throughout the State of New Jersey "south of the shale from the Atlantic coast to the Delaware." The following year (1899) it was recorded by Dr. E. P. Felt from different counties in New York, and as far west as Buffalo. In some places the species was abundant, while in some near-by localities it could not be found, showing that it was still locally distributed through New York. It was afterwards recorded present in Albany, Batavia, Leroy, Syracuse, Riverhead, Oswego, Center, Glendale, Richmond Hill, Penfield, Elmira, Geneva, Ithaca, and about Brooklyn, N. Y. It was also stated to occur in the Niagara district in Canada as far back as Hamilton, Ontario.

An interesting point in regard to the occurrence of asparagus beetles in the Niagara peninsula was that the two species appeared to have arrived almost simultaneously in that region, but that the twelve-spotted form was by far the more common one. In after years different observers noted its further spread in Canada, commenting upon the fact that it led the common species in becoming diffused by natural means. By 1902 it had appeared in Connecticut, at New Haven, and later in other parts of that State.

Since some writers on these asparagus beetles have overlooked the author's second article[b] it may be well to mention that facts additional to those printed in the writer's original article are given therein, including a description and illustration of the egg and its manner of deposition, and what is practically a complete account of the life history of the species, the insect being found to develop and to feed where possible almost exclusively on the berry, although the beetles attack young asparagus shoots before the berries appear.

---

[a] Yearbook U. S. Dept. Agric. f. 1896 (1897), pp. 350–351.

[b] Bul. 10, Div. Ent., U. S. Dept. Agric., pp. 57–59, 1898.

The young larva.—The freshly hatched larva has not hitherto been described. It may be briefly described as follows:

Head rounded, nearly twice as wide as long as seen from above; thoracic plates distinctly separated at the middle, with the intervening space yellow; legs infuscated, clear whitish at sutures. General color very pale yellowish, nearly white, and the surface much wrinkled. Length 1 mm., width 0.35 mm.

U. S. D. A., B. E. Bul. 66, Part II. Issued April 23, 1907.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE WATER-CRESS SOWBUG.

(*Mancasellus brachyurus* Harger.)

By F. H. Chittenden,

Entomologist in Charge of Breeding Experiments.

During the past three years this isopod has attracted very considerable attention because of its occurrence in troublesome numbers in water cress (*Nasturtium officinale*) grown for market in portions of Virginia, West Virginia, and Pennsylvania. The species is purely aquatic, thus differing from our common dooryard sowbugs, which, although most abundant in moist locations, are strictly terrestrial. It belongs to an entirely different family, the Asellidæ, which contains three genera, mostly fresh-water forms, inhabitants of streams, wells, pools, and lakes.

DESCRIPTIVE.

This species is so distinct from the more common sowbugs (Oniscidæ) that a brief description will suffice. Its general appearance is shown, dorsal view, in figure 3. The body is much depressed, and the legs are long and strong. Seen from the side, it is decidedly shrimplike. The peculiar structure of the antennæ may be noticed in the illustration. They terminate in long flagella, composed of many joints. When mature this sowbug attains a length of 13 or 14 millimeters, or a little upward of half an inch, and is a little more than twice as long as wide, and gray in color. This creature is not an insect, but a crustacean, and therefore classed with crayfish and crabs. A detailed description is given by Miss Richardson,[a] who briefly mentions McKees Spring, Gaylord, and Lexington, Va., as localities where this sowbug was "reported injurious to water cress."

By recent correspondence we have obtained necessary information in regard to the habits and manner of operation of this sowbug, and we have also been successful in ascertaining what promises to be a very perfect remedy for the pest in its occurrence in streams and in spring water. It appears to affect cress only below the surface of the water, attacking the roots and lower leaves, and cutting off the stems

[a] Monograph of the Isopods of North America. By Harriet Richardson. Bul. 54, U. S. National Museum, Washington, 1905, pp. 411–412, figs. 460–461.

near the bottom, causing bunches of the plant to float. In portions of streams where these sowbugs have been found most abundantly they are frequently seen crawling in a thick mass at the bottom. They feed, so far as known, exclusively on cress, not being reported as attacking any other form of vegetation.

REPORTS OF INJURIOUS OCCURRENCES.

This sowbug has been observed as a pest since 1902. Our first report of its pernicious habits was made in 1904, when we received specimens through Mr. J. W. Bryan, Anacostia, D. C., from Halltown, W. Va., where it was very injurious to water cress.

In March, 1905, Mr. Powell Arnette reported injury at Gaylord, Va., to cress grown in spring water. The sowbugs were always found in the water and did not attack cress above the surface. After destroying the last vestige of cress in one of his ponds they remained on the bottom "a foot deep," crawling about on the mud.

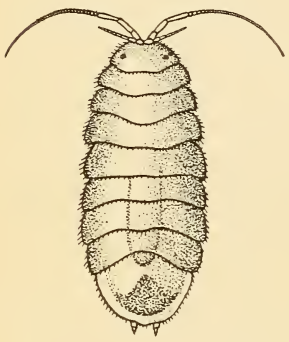


FIG. 3.—The water-cress sowbug (*Mancasellus brachyurus*). Enlarged (after Richardson).

During 1906 (June 18) Mr. John H. Reed, Carlisle, Pa., wrote in regard to this species and its destructive work on water cress in his locality. Specimens were received August 11. The sowbug was observed principally on the roots and lower leaves, crawling up along the stem and cutting off the leaves. August 10 Mr. George C. Jordan, Washington, D. C., sent specimens from Basic City, Va., stating that this "water bug" was devouring his cress beds, and, since a million or more were colonized on the plants, there would be no crop at the rate they were reproducing. When the plants were lifted the sowbugs were observed to drop from them.

METHODS OF CONTROL.

Three ways of controlling this species are suggested. The first and most important consists in a method of growing the water cress so as to eliminate injuries by the sowbug. The second falls under the head of direct remedies, and none of these has as yet given satisfactory results. The third consists in the use of fish or fowls as destroyers. This last means of eradicating the pest has not yet had a fair trial.

The following description of a successful method of disposing of the cress sowbug has been placed at our disposal by Messrs. B. Bryan

& Son, who are practical cress growers and have had several years' experience with the pest:

A METHOD OF GROWING WATER CRESS TO DISPOSE OF THE SOWBUG.

The damage done by the sowbug to water cress has made it our greatest enemy in cress growing, and only after fighting it for four years have we succeeded in finding a way to keep down its numbers so as to be sure of a crop. As cress is ordinarily grown—in lakes or streams of spring water anywhere from 6 inches to 3 feet in depth—it seems impracticable to apply any insecticide. At first we tried to catch the bugs with wire-netting traps placed where the whole stream of water had to pass through them, but the bugs remained among the cress, and we caught only about 20 per cent.

Later, in using copper sulphate to kill moss in the cress, we found that it also killed the sowbugs, snails, etc., when applied freely. Further experiments, however, proved that bluestone could not be applied in deep running water any better than the insecticides previously tried, and when applied in shallow or still water it injured the cress.

The method we are employing at present to fight the sowbug is largely a matter of arrangement of cress beds (see fig. 4), and can be used only where the bottoms of the beds can be graded and drained or where level land adjoins

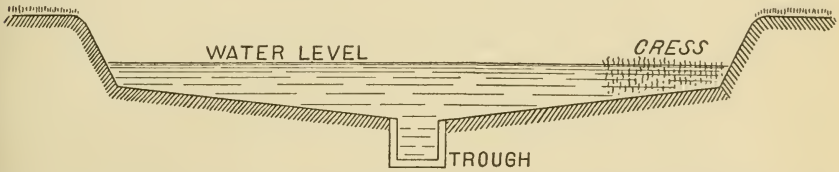


FIG. 4.—Cross section of cress pond showing arrangement for avoiding damage by the water-cress sowbug.

the source of the water supply. We dug long trenches in level land, making them 16 feet wide and about 15 inches deep. Lengthwise they were graded to give a fall of 3 inches in 100 feet, and crosswise to make the center of the trench several inches deeper than the sides. In the center and running the full length of the trench a trough made of three 10-inch boards was sunk below the bottom of the trench in such a way that all of the water might be drained out of the trench through it. Then, with the upper and lower ends of the trench and trough arranged to be opened or closed, the trench could be filled or emptied at will and the flow of water regulated up to 8 inches in depth over the cress. Of course fertile soil was put in the trenches and the cress could be planted either before or after the water was turned in.

With cress beds arranged as above, manipulation to dispose of the sowbugs is simple. By cutting off the water supply and allowing the water to pass out at the lower end of the trench, the sowbugs will collect in the trough, following the receding water, as they can live only in water. No little puddles should remain among the cress, as the bugs will collect in them instead of in the trough. It will be found necessary, also, to use boards to walk on in gathering the cress, as prints of one's boots in the beds would make holes for the bugs to shelter in. The bugs do not move until nearly all of the water is drawn out of the trench. Thus they are collected in a small amount of water in the trough and can then be readily killed with a liberal amount of bluestone, either solid or in solution.

To make the work thorough, water should not be turned into the trench again for twelve or twenty-four hours, in which time the few bugs left among the cress stems will die or find their way to the trough. The trenches can be cleared of bugs in warm weather as frequently as desired, but less danger is done the cress crop if the work is done just after gathering the cress.

The same method of disposing of the sowbugs could be used in greenhouses in the winter, but cress grown in the open air could not be exposed in freezing weather, making the remedy inapplicable in cold weather.

We have not used water in these trenches deeper than 10 inches, and are not able to say how a larger or more rapidly flowing supply of water would act, nor have we grown winter cress in them, as our water supply is insufficient for that purpose.

OTHER REMEDIES.

About the only other remedies which we have been able to suggest are the use of a substance, such as sulphate of copper or chlorid of lime, which might be placed in the water to destroy the pest. As the former has already been tested by Messrs. B. Bryan & Son (see page 13), it need not be mentioned further.

Mr. John H. Reed states that a grower at Healing Springs, Va., has a remedy consisting of a poisonous material which is placed in the water, but he does not know the ingredients nor whether there would be danger to stock drinking the water below the spring. He writes also of the possible use of chlorid of lime. A tank of bleach composed principally of chlorid of lime ran into a creek at Mount Holly Springs, Pa., killed everything that was living in that stream for about half a mile downward, but did not poison stock that drank the water. The bleach came from a paper-mill tank which had burst. If chlorid of lime is tested it should be used on a very small scale at first to note the effect on plant life. It is apt to be harmful to trout and other fish present.

Mr. Reed also suggested the employment of ducks to destroy the pest, but this would necessitate the abandonment of cress culture for a season, as the ducks would injure the condiment both by eating it and by fouling the water.

Among other remedies, we have recommended draining off the water where possible and exposing the sowbugs to the drying effects of the sun.

FISHES AS A POSSIBLE MEANS OF DESTROYING THIS ISOPOD.

In response to inquiry, the following information was received from the Bureau of Fisheries, through Mr. Lawrence O. Murray, Acting Secretary, Department of Commerce and Labor, in regard to the fishes which might be found useful in the destruction of this aquatic isopod in its occurrence on water cress:

Among the fishes which would probably prove most useful for this purpose and with which it is suggested that the Department may wish to experiment

are the fresh-water killifishes *Fundulus notatus*, *F. diaphanus*, and *F. dispar*. The first occurs from Michigan to Alabama, Mississippi, and Texas, and is rather common in small lowland ponds. The second is found from Maine to North Carolina in river mouths, in the Great Lakes, and in practically all of the small lakes in the upper Mississippi Valley. The third occurs in smaller lakes and ponds from northern Ohio to Illinois and south to Mississippi. Specimens of each of these species could be obtained at any one of several small lakes in the northern part of Indiana.

It is probable that some of the catfishes might also be useful in this connection, and it is suggested that it might be worth while to try one or more of the small species known as "mad Toms," belonging to the genus *Schilbeodes*. One or more species of this genus can be found in almost any small, sluggish stream in Pennsylvania, Virginia, and West Virginia.

The writer believes that carp should prove of value in keeping down this cress sowbug, there being one drawback, however, that the carp must be watched to see that they do not develop too rapidly and that they do not attack the cress or make the water muddy. Catfish have been tried and found wanting in the case of the water-cress leaf-beetle, which will be considered elsewhere (pp. 16–20).

THE WATER-CRESS LEAF-BEETLE.

(*Phædon æruginosa* Suffr.)

By F. H. Chittenden,
Entomologist in Charge of Breeding Experiments.

INJURIOUS OCCURRENCE.

Among plant-feeding native insects which have recently appeared in new rôles is a little blackish leaf-beetle, *Phædon æruginosa* Suffr., which was reported for the first time as injurious to water cress (*Nasturtium officinale*) in Pennsylvania, in 1903.

During September Mrs. Hannah B. Hannum, Brandywine Summit, Pa., sent larvæ and adults of this species, with statement that they were devastating her water-cress pond. Both larvæ and beetles fed chiefly on the lower side of the leaves. In confinement they continued feeding, attacking the stalks also. The larvæ all reached development about the same time, being fully matured September 11 and 12, on the last of these two days crawling about the rearing jar and ceasing to feed. The pupal period was not observed, but it probably lasted ten days or a fortnight, as the weather was cool. The beetles continued for some time in our rearing cages, frequently pairing, but depositing no eggs.

August 19, 1904, Mrs. Hannum sent additional specimens of this species in the beetle and nearly grown larval stages. It was noticed that the beetles did not swim rapidly, but steadily, and they were seemingly not discomposed by being somewhat out of their natural element. It seems probable that they fly from plant to plant, and like most beetles undoubtedly are able to float for many hours, and perhaps even swim short distances until they reach a landing place. September 13 our correspondent sent still another lot of this species, mostly beetles, but a number of larvæ were included.

Specimens of the larvæ of a syrphus fly accompanied this sending and probably fed at times on the small larvæ of the beetle.

DESCRIPTIVE.

The beetle.—This species belongs to the tribe Chrysomelini of the family Chrysomelidæ. It is classified in our publications on the Coleoptera of America north of Mexico with Plagiodera, but European systematists place allied forms in the genus Phædon Latr., which now comprises seven species occurring in our country. They are very small semiglobose forms. The outline is oval, with the thorax

narrowed anteriorly and the apex margined. The elytra have eight punctate striæ, with a short subsutural and submarginal row of punctures. The third joint of the tarsi is emarginate apically.

The present species measures a scant one-eighth of an inch in length (3 mm.), is shining bronzy black, and has the elytral intervals apparently smooth, but in reality faintly rugulose when highly magnified, while the thorax is microscopically reticulate. The original description appeared in 1858.[a]

The egg.—The eggs have not come under observation. They probably resemble those of the European *Ph. armoraciæ* L., described by Fryer as "elongated oval and of a dark orange color."

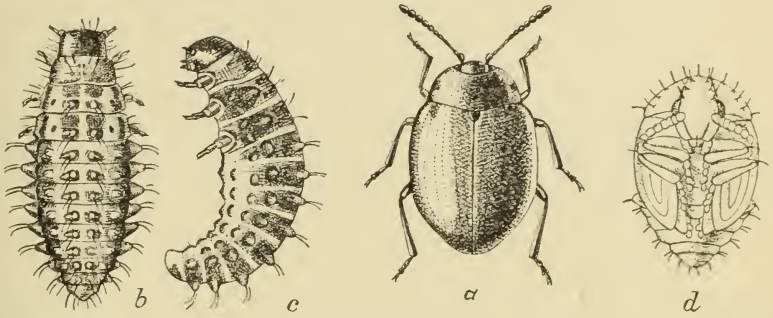


FIG. 5.—The water-cress leaf-beetle (*Phædon æruginosa*): *a*, adult; *b*, larva, from above; *c*, same, from side; *d*, pupa. Enlarged twelve times (original).

The larva.—The larva appears somewhat like that of a related genus, Galerucella, only that it is very much smaller. It is about three or four times as long as wide, depending upon whether it is somewhat contracted or fully extended. The head is subtruncate in front, with the antennæ lateral (in preserved specimens). The head is shining black, and the remainder of the body very dark brown or brownish black relieved by lighter areas between the segments. The first thoracic segment is a little wider than the head; the second considerably wider than that, and the third widest, being nearly as wide as the first two abdominal segments. The second abdominal is widest, and at the same time the widest part of the body. The surface is sparsely covered with long hairs placed on piliferous tubercles, which are arranged some distance apart, as shown in figure 5, *b*. The tubercles on the sides of the dorsum are sometimes very prominent, and the larva is able to extend these, possibly, at will. From the abdominal segments large tubercular sections bearing hairs at their summit extend on each side. The anal segment is pale, like the ventral surface, which bears dark piliferous tubercles. Length, 5 mm.; width, 1.2–1.5 mm.

[a] Ent. Zeitung. Stettin, Vol. xix, pp. 395, 396, 1858.

The pupa.—The pupa is illustrated by figure 5, *d*, which will answer better than a verbal description. The color is yellow, and the length is slightly less than that of the adult.

The distribution of this species is probably moderately wide and additional study must be given this subject. At present we know of its occurrence in the District of Columbia, in Massachusetts, and probably in West Virginia.

LITERATURE.

Brief mention of the occurrence of this leaf-beetle as an enemy of water cress in Pennsylvania in 1903 was made by the writer,[a] but Mr. Frederick Knab, of this office, mentioning the same species as *Plagiodera viridis*, has recorded[b] its occurrence in great abundance upon water cress near Springfield, Mass., in 1902. The identity of the species in question has been verified by the comparison of specimens, and Mr. Knab's record was evidently made on the assumption of Crotch[c] that *æruginosa* was merely a variety of *viridis*.

HABITS OF THIS AND A RELATED SPECIES.

We can not at the present writing give an approximate statement of the life-history of *Phædon æruginosa*, and hence must depend on what is known of the related *Ph. armoraciæ*, which is common to both continents.[d] This latter has evidently been introduced into this country, but its habits have apparently not been studied here. It is known in England as the blue beetle and mustard beetle,[e] and is of considerable importance locally, in some seasons ravaging entire fields of mustard, cress, cabbage, and kohlrabi. It passes the winter as adult, reappearing in spring on cruciferous plants. Fryer stated that in the three years prior to 1881 the Isle of Ely, England, suffered from the ravages of this species, entire fields being injured. Mustard was attacked at about the time of the formation of the seed pod and after the stalks were stripped nearly to the cuticle the beetles transferred their attention to kohlrabi, which they completely consumed, at first attacking the leaves and afterwards the bulbs, leaving nothing but bare stalks.

The water-cress leaf-beetle is doubtless no exception to the general rule among most Chrysomelidæ and other species of Phædon, in laying its eggs on the under side of the leaves. Both larvæ and

---

[a] Ybk. U. S. Dept. Agric. f. 1903 (1904), p. 564; [b] Entomological News, March, 1903, p. 89; [c] Crotch, Proc. Acad. Phila., 1873, pp. 54, 55; [d] *Phædon armoraciæ* L. syn.: *Plagiodera cochleariæ* Panz., Gyll.; *Phædon betulæ* Küst. It is not the same as *cochleariæ* Fab. [e] Fryer and others have given accounts of this species in The Entomologist (Vol. XIV, pp. 44, 187, etc.).

adults attack the cuticle of the stem after feeding on the leaves, as has been noticed in the case of *armoraciæ*. E. A. Fitch has observed the partiality of the latter for water cress and other crucifers which grow in watery places and mentions the destruction of an entire crop of horseradish.

Kaltenbach [a] records, according to Gyllenhall and his own observations, *Veronica beccabunga*, *Cardamine amara*, and *Cochlearia armoracia* or horseradish as food plants, and states that the larva undergoes metamorphosis in the earth, the pupa state lasting fourteen days. Cornelius [b] is cited as having observed two generations, the spring generation being found in May and June and the second in September. Thomas H. Hart records the water starwort of England (*Callitricha verna*) as another host plant. T. R. Billups,[c] an entomologist as well as truck grower, mentioning this species as *Phædon betulæ*, states that it is "one of the greatest insect pests the market gardeners around London have to contend with." Our American species undoubtedly hibernate as adults and appear in early spring under boards and similar shelter.

METHODS OF CONTROL.

How to successfully control this insect under ordinary conditions is quite a problem. Paris green was tried by our correspondent, mixed with flour and sprinkled over the plants when the dew was on, and this reduced the numbers of the insect somewhat. Owing to the moist condition of the plants, however, the flour formed a paste which stuck like glue, and it was therefore abandoned. Applied in water it rolled off the plants. We were not informed if this application was made with a spraying machine. If the plants were sprayed lightly with a fine spray, it might answer, or, better, Paris green dry with only 20 parts of flour, or plaster or air-slaked lime. An arsenical should not be used within about a week of the time of cutting the cress for market. In the case of Paris green there is practically no danger of poisoning even if it were used later, as the washing which is given the cress will carry away all perceptible traces of the poison.

If conditions should be such that the pond or stream in which water cress infested by this species is growing could be completely overflowed, it would cause the insects to rise to the surface, and in the case of running water would wash them downstream. Flooding alone might not entirely solve the problem, as these beetles are able to survive considerable immersion.

When the cress is grown in sufficiently large bodies of water ex-

[a] Pflanzenfeinde, p. 26; [b] Stett. Ent. Zeit., 1863, p. 123; [c] The Entomologist, Vol. XIV, 1881, p. 236.

periments should be made with some of the fish mentioned on page 15 as possibly useful for destroying cress insects. Ducks might also be found valuable. Catfish were tried, but without avail.

Mrs. Hannum has recently written that she attained the greatest success by growing the water cress in running water which carried the beetles away. In cold weather it was necessary to plant in houses where the cress did well until the coming of warm and dry weather, when the beetles would sometimes clean it out almost entirely, leaving only the roots. By tearing the cress out of the houses and in ponds which were not exposed to running water she could replant her beds, and hoped in time to get rid of the pest.

U. S. D. A., B. E. Bul. 66, Part III. Issued August 31, 1907.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE CRANBERRY SPANWORM.

(*Cleora pampinaria* Guen.)

By F. H. Chittenden,

Entomologist in Charge of Breeding Experiments.

A brownish spanworm has been observed by the writer during recent years on asparagus in the District of Columbia in such numbers as to indicate that it is especially attached to this crop, at least in this region. In consideration of the fact that so few insects attack asparagus, the accompanying account has been prepared. The species appears to have attracted no attention since 1884,[7a] when it was considered in relation to its appearance in cranberry bogs. From material recently collected, several facts hitherto unrecorded have been gained, and there are a number of unpublished notes of the Bureau showing a tendency on the part of the species to become omnivorous. At any rate it is not confined to cranberry, as the name given above would imply, nor to strawberry, as might be inferred from another name, "brown strawberry spanworm," which has also been given it. The list of food plants which will presently be furnished shows a considerable range. Owing to the fact that the insect has not often been observed concentrated on any single crop, little mention of it has been made in literature by economic writers. Cranberry is a favorite food plant, and is sometimes injured to a considerable extent, especially in Massachusetts.

DESCRIPTIVE.

This insect belongs to the lepidopterous family Geometridæ, the larvæ of which are well known under the common names of spanworms, measuring-worms, inch-worms, and loopers.

The moth which produces this spanworm is quite variable in color and markings. The average expanse of wing is from a little less than an inch to upward of an inch and a fourth (22–32^{mm}), but may exceed this, attaining, according to Dr. A. S. Packard,[4] a measurement of an inch and a half. The ground color of living specimens is pale

[a] The numbers in superior type refer to corresponding numbers in the appended bibliography, p. 27.

leaden gray, and of old mounted material a duller gray, thickly diffused with black and brown dots and other markings more or less constant, forming irregular lines across both fore-wings and hind-wings. On both there is a marginal regular scalloped black line and within this a strongly dentate or zigzag white line. The general pattern of the wings varies considerably from that shown in figure 6, *a*, which represents the female. The color of the body is similar to that of the wings. The first abdominal segment is white above.

The sexes can be readily distinguished by the antennæ. Those of the female are filiform and tessellated and those of the male rather strongly pectinate, or feathered. The structure of the latter is shown at *e* and *f*, figure 6.

" It may be known," says Packard, " by the very distinct line at the base of the abdomen, the basal wing beyond being usually white, and the underside of the wings having a broad marginal shade, while the third line on the fore-wing is deeply but quite regularly sinuate and near the costa acutely dentate."

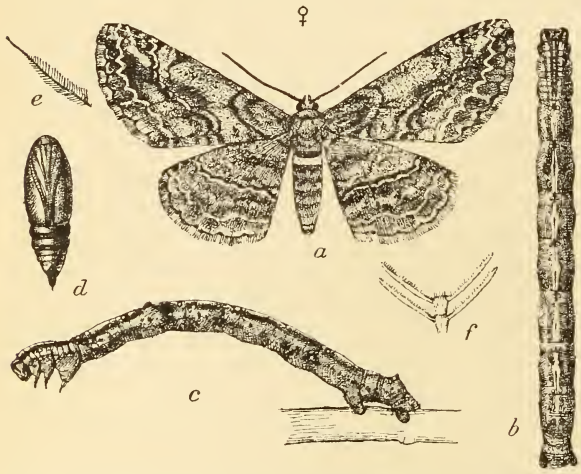


FIG. 6.—The cranberry spanworm (*Cleora pampinaria*): *a*, Female moth; *b*, larva, dorsal view; *c*, larva, lateral view; *d*, pupa; *e*, male antenna; *f*, enlarged joints of same. All enlarged; *e*, *f*, more enlarged (original).

A number of synonyms are credited to *Cleora pampinaria*. It has indeed received five specific names. As three of these were given by Guenée, it is of itself indicative of the variation of the moth. The list follows:

Boarmia sublunaria Gn., Spec. & Gen., IX, 248 (1857); *B. frugallaria* Gn., Spec. & Gen., IX, 246 (1857); *B. collecta* Wlk., Cat. Brit. Mus., XXI, p. 397 (1860); *Cleora tinctaria* Wlk., Cat. Brit. Mus., XXI, p. 486 (1860); *Boarmia fraudulentaria* Zeller, Verh. zool.-bot. Ges. Wien, XXII, p. 492 (1872); *Cymatophora pampinaria* Pack., Mon. Geom., p. 432 (1876).

The egg appears not to have been described.

The larva.—The larva resembles those of other geometrids in being of elongate form, about nine times as long as wide, with the three pairs of thoracic or front legs bunched closely together near the head, and in having only two pairs of prolegs, or unjointed legs, at the

opposite extremity. The color varies to a considerable extent from mottled pale yellowish to brown, often with an olivaceous or greenish tint. Those which have been recently captured in the District of Columbia are reddish brown, mottled, streaked, and lined with lighter yellowish, red, and black. The head is strongly marked with transverse irregular black bands. The thoracic segments are marked above by a pair of thin median longitudinal lines. The second abdominal segment bears on the dorsal surface a pair of prominent, widely separated, mostly black tubercles, but in some individuals these are wanting. The penultimate segment also bears above a smaller pair of black tubercles. The larva when full grown measures an inch to upward of an inch and a fourth in length (25–33^{mm}) and the greatest diameter is about one-eighth of an inch (3^{mm}). The singular construction of the legs, or rather the lack of the intermediate legs usually present in caterpillars of other families, is the cause of the peculiar motions of the spanworms in crawling about in search of food, which have given them their popular names. When in motion a larva extends its body to full length, then brings the posterior legs close to the anterior ones, causing the body to loop in the center. The body is then stretched out again, these actions being repeated alternately.

When this spanworm is in repose it attaches itself to the foliage—for example, to the stem of asparagus—by means of its anal pair of legs and stretches out its body rigidly and at an angle so that its natural colors harmonize with the foliage or with the landscape. On this head Doctor Smith has remarked that on a section of cranberry bog on which this species is feeding the observer may stand in the midst of thousands of them and see none until something starts them into motion. Then it appears almost as though the entire bog were alive. As the spawnworms hang somewhat tenaciously to their food plants, they are undoubtedly present frequently in numbers without anyone being the wiser.

The half-grown larva is described by Doctor Forbes.[8]

The pupa, shown, ventral view, in figure 6 at *d*, is of robust form, light greenish brown in color, and a little less than half an inch in length (12^{mm}) and about a third of that (4^{mm}) in width.

DISTRIBUTION.

The wide distribution of this insect is shown by the following list of localities, based upon Doctor Packard's list, where the authorities for each locality are given: Maine; Amherst, Cape Cod, Cotuit, Natick, Mass.; West Farms, Center, Albany, and Brewster, N. Y.; Philadelphia, Pa.; Lansing, Mich.; Dayton, Ohio (Pilate); Glencoe, Nebr.; Cadet, Mo.; Centralia and elsewhere in Illinois; Washington and Brookland, D. C.; Georgia; Calhoun, Dawson, and De-

mopolis, Ala.; Lake Bearsford, Florida; Bastrop County and elsewhere in Texas.

The above localities indicate a distribution ranging from the transition life zone through the upper to the lower austral. The occurrence of the species in Florida, Alabama, and Texas would indicate that it is to be found throughout the Gulf region. The insects observed by Glover were stated to appear in the Carolinas, Georgia, and Florida in early October.

BIOLOGIC LITERATURE.

The spanworm under consideration was described under the name of *Boarmia pampinaria* by Guenée in 1857.[2] In 1876 Dr. A. S. Packard gave a detailed description of the moth, with a consideration of its distribution and remarks on the larva and pupa, the former being stated to feed on pear.[10] In 1881 Dr. G. H. French[6] had a note on the larva observed feeding on willow and geranium; larvæ transformed to pupæ September 16 and October 2, and the imagoes issued April 17 of the following year. During the year 1883 this species was observed by Dr. J. B. Smith,[7] then a temporary agent of this office, doing injury at Cotuit, Mass. During that year the spanworms were so abundant in the cranberry bogs in that vicinity that their numbers could be compared only to the army worm (*Heliophila unipuncta* Haw.). In the case in question they began in a space about a rod square, devoured that, and spread in a direct line across the bog. The number of moths that would have been produced from these insects should they have been permitted to transform was described as being "frightful." A rather full account by Dr. S. A. Forbes followed in 1884,[8] in which the statement was made that the larva was found in midsummer feeding on leaves of strawberry in southern Illinois. Larvæ obtained August 1 pupated on the 11th, and the moths emerged on the 22d, giving eleven days as the pupal stage at that season. Larvæ collected September 6, about half grown, were believed to represent a second generation. The larva of this species came under the observation of the writer on asparagus first in 1897.[11] In 1899 Doctor Lugger[12] stated that the caterpillars were found on apple and blackberry, and that there were at least two generations annually.

As this is one of the commonest species of its genus, of wide distribution, and authentically determined as living on cotton, there seems little doubt that it was the type of Glover's account of "the larger spanworm," figured and described in his accounts of insects frequenting the cotton plant, published in 1856[1] and again in 1878.[5] A curious blunder was made by M. D. Landon, who figured this species as the "cotton caterpillar (*Noctua xylina*)" in 1865,[3] this illustration being a crude copy taken from Glover's first or 1856 account of this spanworm.

UNPUBLISHED OFFICE NOTES.

June 5, 1879, we received from Mr. William Trelease, then at Dawson, Ala., larvæ found feeding on cotton. June 12 a larva kept under observation changed to pupa, and on June 26 the moth issued, this individual having passed 14 days as pupa. The same year the moth was reared on several occasions from material obtained on red clover in the District of Columbia by Messrs. Pergande and Howard. June 28 the moth issued from the pupa. August 15 the larva was observed feeding; changed to pupa August 25, and issued as moth March 1 of the following year. August 29 the larva was observed feeding; changed to pupa September 4, the moth issuing March 22 of the next year.

February 6, 1880, we received from Lake Bearsford, Fla., from Prof. J. H. Comstock, a larva obtained on orange.

There are also reared specimens of moths in the U. S. National Museum bearing labels showing the rearing of moths and occurrence of larvæ on different plants, as follows: On locust, May 6, 1893, District of Columbia; hickory, November 24, 1894, Cadet, Mo., and August 4 of the same year on pear, locality presumably the District of Columbia. There is also a specimen labeled "on guava," probably from Florida.

August 6, 1904, specimens of this spanworm were received from Calhoun, Ala., where they were found feeding on cotton and were mistaken for the cotton leaf-worm (*Alabama argillacea* Hbn.). The adult issued August 29. Larvæ were about full-grown when received, August 9, and it seems probable that they underwent a short stage of æstivation before transforming to pupæ, as the pupal stage is less than 20 days in midsummer.

During the first two weeks of October for several years larvæ have been observed on asparagus grown in the District of Columbia, the species appearing in moderate numbers. The first moth that has been reared from October-collected larvæ appeared in January, and others appeared in February. As this was in confinement the dates were not natural ones.

LIST OF FOOD PLANTS.

It is, as previously remarked, owing to the omnivorous habit of this species, causing a distribution of attack, that noticeable injury has not been ascribed to it elsewhere than in cranberry bogs. It is common enough in the vegetable and truck garden, but not confined to any particular place on the farm, occurring in orchards, on forest and shade trees, and on other plants. The list of observed food plants includes asparagus, strawberry, blackberry, ornamental geranium, apple, pear, orange, willow, hickory, cranberry, honey locust, cotton, clover, and guava. As a rule the larvæ confine themselves to the

foliage of these plants, but Glover states that they sometimes feed upon the petals of the flowers of cotton, although doing little harm to the general crop.

THE INSECT'S LIFE HISTORY.

Our knowledge of the life history of this species is somewhat incomplete. The repeated rearing of moths in early spring and the occurrence of larvæ in the latter part of June in Massachusetts as recorded by Smith, as also in the District of Columbia and elsewhere as late as October, noted by the writer and others, show at least two generations in the Northern States, while the record of the occurrence of the moths in March in Texas (by Belfrage) would indicate that in the Gulf States there may be an additional generation. It would seem practically impossible for larvæ hatching from eggs deposited in early spring to require until late October to attain maturity, hence the natural inference of two generations for a climate like the District of Columbia. The cranberry growers of Massachusetts claim two generations for that State, one appearing as larvæ in June and early July, the other in the latter part of August.

The eggs are unknown, and the periods of egg and larva have not been ascertained, but the pupal condition has been observed to be passed, for the first generation, in from 11 to 14 days, while the over-wintering pupa consumes five or six months in the District of Columbia, a shorter time farther south, and a longer time northward.

The date of the appearance in the North of the first moths has not been learned positively nor the natural time of emergence of the first new generation of moths.

NATURAL ENEMIES.

Doctor Smith[7] has stated that the larvæ of this spanworm are checked by parasites, but that in some localities almost every year they become numerous enough to be destructive. In some years, however, in the cranberry bogs of New Jersey they are not seen at all, showing great scarcity, due probably in part, at least, to natural causes. Only one parasite for this species is known, namely, *Exorista bourmiæ* Coq., a tachina fly reared at this Department from Cotuit and other localities in Massachusetts several years ago.

REMEDIES.

This species is not difficult to control on asparagus or other truck crops. As it feeds in free exposure on the foliage, spraying with Paris green or arsenate of lead will destroy it, and when either of these insecticides is used for the asparagus beetles it will kill all of the spanworms which may be present. The Paris green may be

used at the rate of 1 pound to about 100 to 150 gallons of water, and the arsenate of lead at the rate of about 1 pound to 25 to 50 gallons of water. The same remedies will apply equally well to the occurrence of this species in cranberry bogs.

BIBLIOGRAPHY.

1. Glover, Townend. Report Commissioner Patents, p. 92, Plate VIII, fig. 4, 1855 (1856).

Probably this species. Appears in Carolinas, Georgia, and Florida early in October and feeds upon the petals of the cotton flower; larva and adult described and figured.

2. Guenée, M. A. Species Général des Lépidoptères, Vol. IX, Phalénites, pp. 245, 246, 248, 1857.

Original description as *Boarmia pampinaria* from near Baltimore, as *B. frugallaria* from Georgia, and as *B. sublunaria* from North America.

3. Landon, M. D. Rept. Comm. Agr. f. 1864 (1865), p. 90.

Erroneously figured as the "cotton caterpillar (*Noctua xylina*)."

4. Packard, A. S. Report U. S. Geological Survey Terr., Hayden, Vol. X, pp. 432, 442, Plate XI, fig. 20, 1876.

Technical and detailed description of moth; synonymy; distribution and note on larva and pupa, the former feeding on pear.

5. Glover, Townend. Cotton and its principal injurious insects<Washington, D. C., Plate VII, figs. 6, 7, 8, 1878.

Figures larva, chrysalis, and moth; found early in October in Georgia feeding on flowers of the cotton plant.

6. French, G. H. Papilio, Vol. I, p. 82, 1881.

Notes on larva found feeding on willow and geranium.

7. Smith, J. B. Bul. 4 (o. s.), Div. Ent., U. S. Dept. Agr., pp. 26–28, 1884.

A two-page account in reference to injuries to cranberries; description of larva; referred to as *Cymatophora pampinaria;* remedies.

8. Forbes, S. A. Thirteenth Rept. State Entomologist Illinois, pp. 76–78, 1883 (1884).

A rather full account. Larva found frequently in midsummer in southern Illinois feeding on leaves of strawberry; description of larva, pupa, and imago (quoted from Packard).

9. Forbes, S. A. Trans. Miss. Valley Hort. Soc., Vol. II, p. 235, 1884.

Quotations of first two paragraphs of No. 8.

10. Packard, A. S. Fifth Report U. S. Ent. Commission, p. 654, 1890.

Included in a list of insects affecting honey locust (*Gleditschia triacanthos*).

11. Chittenden, F. H. Bul. 10, n. s., Div. Ent., U. S. Dept. Agr., p. 61, 1898.

An unknown geometrid larva feeding on asparagus; subsequently ascertained to be this species.

12. Lugger, Otto. Fourth Rept. Entomologist State Exp. Station Minn., pp. 187, 188, fig. 188, 1898 (1899).

Notes on the moth; caterpillar found on the apple and blackberry. Short general account.

13. Smith, J. B. Farmers' Bulletin 178, U. S. Dept. Agriculture, pp. 19–21, 1903.

Account of injuries to cranberry, life history, and remedial measures.

THE STRIPED GARDEN CATERPILLAR.

(*Mamestra legitima* Grote.)

By F. H. Chittenden,
Entomologist in Charge of Breeding Experiments.

A strikingly beautiful black and yellow striped caterpillar is frequently found in gardens, and occasionally in such numbers as to attract attention. It is a general feeder, like most of its kind, but is somewhat partial to asparagus, cruciferous plants, peas, and other leguminous vegetables. Its occurrence in the District of Columbia in some numbers, especially on asparagus, has permitted a study of the species, which adds somewhat to what has previously been published. Only a few short notices of this insect have appeared in publications of the Department of Agriculture or elsewhere, to the writer's knowledge. The following somewhat brief account is therefore presented.

This species is a noctuid, related to the cutworms, and is congeneric with the zebra caterpillar (*Mamestra picta* Harr.). The moth was originally described in 1864,[a] the species at that time being known from the middle and eastern States, where it was stated to be common. It is also recorded as occurring in the northern States. Evidently, considering its numbers in the Gulf region, it may be found in most States east of the Mississippi River Valley.

DESCRIPTIVE.

The moth is quite prettily marked, as can be seen by referring to figure 7, *a*. The prevailing tint of the fore-wings is a light lead color, marked with velvety-black and brown spots, the pattern varying somewhat but usually about as figured. The lower wings are fawn colored, with dusky margins, and the veins are moderately prominent. The females, as is usual with this group, have the abdomen as illustrated, while the males have abdomens with bushy tips. The wing expanse is a little more than an inch and a quarter.

The eggs.—No description of the egg is available at the present writing.

The larva is also a pretty form and its markings recall the zebra caterpillar. It will be noticed by the figure (fig. 7, *b*, *c*) that there is considerable difference, however, and the two species are not at all likely to be confused by anyone who carefully examines them. The present species has a larger and wider head and is darker than is usual with the common zebra caterpillar. The appearance of the head from in front is shown at *d*. The stripes with which the body is

[a] *Apamea legitima*, Proc. Ent. Soc. Phila., Vol. III, p. 82.

ornamented are black and yellow, as with the zebra caterpillar, but the lateral stripe is divided into two portions, the upper one lighter than the lower, and the entire lateral surface when marked consists of regular stripes, whereas in the other species these stripes are broken up.

The pupa, when mature, is nearly black in color, and has the appearance illustrated (fig. 7, *e*). It measures about five-eighths of an inch in length, including the tips.

BIOLOGIC NOTES.

This species was briefly mentioned as having been found by the writer in the larval condition on asparagus at Marshall Hall, Md., in October, 1896.[a] At that time it was impossible to ascertain whether or not it bred from eggs deposited on this plant, but later observations conducted in company with Mr. F. C. Pratt during the first and second weeks of October show conclusively that such must be the case, as larvæ were found in the greatest abundance on three large patches of asparagus at Brookland, D. C. They usually occurred singly, but occasionally in pairs.

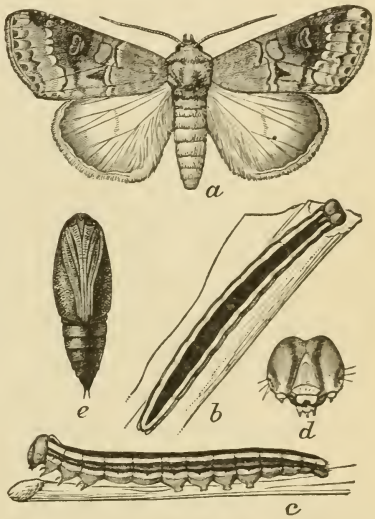


FIG. 7.—The striped garden caterpillar (*Mamestra legitima*): *a*, Adult; *b*, larva from above; *c*, same from side; *d*, head of same from front; *e*, pupa. All natural size except *d*, which is enlarged (from Howard).

During the heat of the day, in the moderately cool and seasonable Indian summer weather usual at Washington at that time of the year, many larvæ would be found stretched out upon dry sprigs of asparagus, and in spite of their bright colors they would easily have escaped the observation of anyone without experience in insect collecting. The larva, in fact, furnishes a good example of protective coloration. An individual would be in plain sight, and then if one's eyes were directed elsewhere for a moment it would sometimes be difficult to find it again, although it might be within a foot of the observer.

Larvæ obtained October 7 and later were kept feeding on asparagus in our rearing cages until the third week of October, when they descended to the earth and soon afterwards assumed the pupal condition. The exact date of the assumption of the chrysalis form was not ascer-

[a] Bul. 10, n. s., Div. Ent., U. S. Dept. Agr., p. 60.

tained, but it was about the 21st of October, which would give a period for the pupa of ten months, as the moths of this lot began issuing August 21.[a]

One individual transformed to pupa October 17 and the imago issued August 24 of the following year.

October 15, 1898, the larva was brought to the writer by Mr. P. H. Dorsett, from his greenhouse at Garrett Park, Md., where the species was feeding on the foliage of violet. The same year, November 3, this larva was found rather abundantly by Doctor Howard in tobacco fields in southern Virginia, near the North Carolina border line, upon the leaves, which in some cases were badly ragged.[b] The first moths issued in July.

During 1900 and 1901 correspondence was had in regard to this caterpillar with Mr. H. Walter McWilliams, Griffin, Ga., who sent specimens, as also larvæ of the so-called cotton cutworm (*Prodenia ornithogalli* Guen.), with which the insect was associated in both years. The caterpillars were noticed there in greatest numbers during November, and both species were reported as destroying a number of garden crops, among which were cabbage, collards, turnip, ruta-baga, rape, peas and related plants, as also some other vegetables. Mature larvæ were seen as late as the last week of November.

Among other office records are two which also have a bearing on the biology of this species. One of these was made by Mr. Theo. Pergande, who found the larvæ in the District of Columbia feeding on blackberry and on flowers of a goldenrod (*Solidago* sp.). The other is a short note by Mr. F. M. Webster upon the rearing of the moth in spring from the seed pods of milkweed (*Asclepias incarnata*), near Lafayette, Ind. "The larva appeared to subsist upon the seeds, the pods being attached unopened to the wrecked plant."[c]

October 21 the larva was found at Washington, D. C. We have no further records in regard to the habits of this species other than the capture of moths in the District of Columbia July 25, August 22 and 25, and September 2, and there are specimens also in the U. S. National Museum from Lewis County, N. Y., July 4, collected by O. Meske, and others from New Jersey without definite locality. The species is also said to occur at Portland, Oregon. It is interesting to note that among these specimens are inflated larvæ and mounted heads labeled "pretty cutworm," which might be termed a manu-

[a] The rearing jar was kept under somewhat unnatural conditions, at times too warm and dry, but the effect of one condition might have been counteracted by another, and the date of issuance of the adults was not far from that which would be assumed in nature—more likely earlier than otherwise.

[b] Yearbook U. S. Dept. Agric. for 1898, p. 142.

[c] Insect Life, Vol. II, p. 382, 1890.

script name, as I do not find this insect mentioned under this cognomen in print. With present knowledge of the species it can not properly be classified as a cutworm.

Among the files of the Department of Agriculture there are a few notes which are of interest as showing the cycle of periods from egg to about the last stage of the larva. These notes were made in 1882 by Mr. Albert Koebele, and the mounts which were made with them are not sufficiently fresh for description. From these notes the following is taken:

Moths collected at sirup, near the District of Columbia, September 16, were placed in a rearing jar with grass, where two batches of eggs were laid between 11 and 12 o'clock at night, one of these being deposited around the stem of grass.

September 18 the eggs hatched, showing the egg period to be only 2 days. On the 21st the larvæ had completed the first molt, making the first larval instar 3 days. September 23 the second molt was observed, which gives 2 days as the second larval instar. September 27 larvæ changed their third skin, leaving 5 days as the period of the third instar.

October 1 the fourth molt occurred, making 4 days for the fourth instar. By October 9 all the larvæ had changed the fifth skin, when they developed cannibalistic tendencies and were removed to a larger jar. The period of this instar was 8 days. The remaining larvæ refused to eat and finally died, so that the complete life cycle could not be ascertained.

NATURAL ENEMIES.

Soon after bringing larvæ in from the field some were noticed to be dying from fungous attack. In the asparagus fields *Estigmene* (*Leucarctia*) *acræa* Dru. and *Dissosteira carolina* L., the salt-marsh caterpillar and Carolina locust, respectively, were also dying in considerable numbers, and it was conjectured that the disease might have originated with these and spread to the Mamestras. After the diseased caterpillars had been frequently removed, however, the fungous attack abated. Specimens of infected larvæ were referred to the Bureau of Plant Industry, and the fungus was identified by Mrs. Flora W. Patterson, assistant pathologist, as an undescribed species of Verticillium. At another time larvæ which showed signs of disease after capture were examined by Mrs. Patterson, who recognized the presence of the fungus *Sporotrichum minimum* Speg. A larva, when placed with diseased insects, including some of its own species, did not contract the fungous disease, from which it seems probable that the disease is not readily communicable, and hence of no use as a possible means of destroying this species.

SUMMARY OF HABITS.

From present knowledge of the caterpillar two generations annually are indicated, although only one has been observed. Moths have been reared by the writer in July and August and they have been captured out of doors during the same months and in September. From available data it would appear that an average life history would be about as follows: Egg period, 3 to 5 days; first larval instar, 3 days; second larval instar, 2 days; third, 5 days; fourth, 4 days; fifth, 8 days, and pupal stage, 7 to 10 months. Hibernation occurs in the pupal stage.

The observed food plants include asparagus, cabbage, collards, turnip, ruta-baga, rape, peas and related plants, greenhouse violet, tobacco, grass, and blackberry. Of wild plants, golden-rod and milkweed have been observed, the larva attacking the flowers of the former and the seed pods of the latter.

METHODS OF CONTROL.

Although the early habits of this species as it occurs in the field have not been observed, there is no doubt that, like the zebra caterpillar, the young when first hatched are gregarious for some time, and hence may be easily discovered and destroyed by mechanical means or by arsenicals. All of the caterpillars of this class readily succumb to arsenical poisons, and for this species in its occurrence on asparagus and some other plants arsenate of lead is to be preferred. It may be used at the rate of about 1 pound combined with 15 to 25 gallons of water or Bordeaux mixture. If an adhesive resin soap, such as resin fish-oil soap, is added, it makes this mixture all the more permanent, and a single application is then all that is necessary. Paris green may be used in the same manner at the rate of 1 pound to 100 or 150 gallons of water. It is evident that this species, like the zebra caterpillar, does no particular harm as a rule in its first generation, but is much more abundant in the second or late fall generation, when certain plants are injured by it. Owing to the difficulty of locating the larger larvæ, it is evident that hand-picking would not be applicable for them in their later stages.

U. S. D. A., B. E. Bul. 66, Part IV. Issued January 27, 1909.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE LEAFHOPPERS OF THE SUGAR BEET AND THEIR RELATION TO THE "CURLY-LEAF" CONDITION.

By E. D. Ball, Ph. D.,
Special Field Agent.

INTRODUCTION.

Ever since the introduction of the sugar beet into the intermountain region more or less loss has resulted each season from a condition called "curly-leaf," or "blight." (See Pl. I, fig. 1, *j*; Pls. II, III; Pl. IV, fig. 1.) Around Grand Junction, Colo., the beet growers have suffered frequent losses from this source. Supt. George Austin, of the Utah Sugar Company, reported a serious loss around Lehi, Utah, in 1897. In 1903 the beet crop in Sevier County, Utah, was somewhat injured, the next year the damage was worse and more widespread, while in 1905 it extended throughout the State of Utah and the adjoining portions of Colorado and Idaho.

Until 1905 the condition had been looked upon as a result of some fungous or bacterial disease, or due to a soil or climatic condition. During that season it was noticed for the first time that a leafhopper (*Eutettix tenella* Baker) was present in large numbers in the fields where this damage was the worst, and the writer, in connection with his duties as entomologist of the Utah Agricultural Experiment Station, commenced an investigation of the insect and its relation to the damage. It was then too late to work out its life history, so most attention was paid to a study of its relation to the "curly-leaf" condition and to experiments with remedies. This investigation was continued in 1906 and 1907, in cooperation with the Bureau of Entomology, and the life history was worked out. Owing to the small number of insects appearing these two seasons, little more was done with remedies, but many new facts were learned in regard to methods of attack and the causes of the injury.

The writer's attention was first called to the "curly-leaf" in August, 1900, by Prof. F. H. Shaw, then chemist of the Grand Junction (Colo.) Sugar Factory. A careful examination was made at this time and again in succeeding years, but no explanation was found

for this condition. These examinations were, however, always made late in the season after the curly-leaf character had become general and after the greater number of insects had disappeared. Examination of the beets always revealed a few specimens of *Eutettix tenella* along with other leafhoppers and miscellaneous insects, but never in sufficient number to cause suspicion.

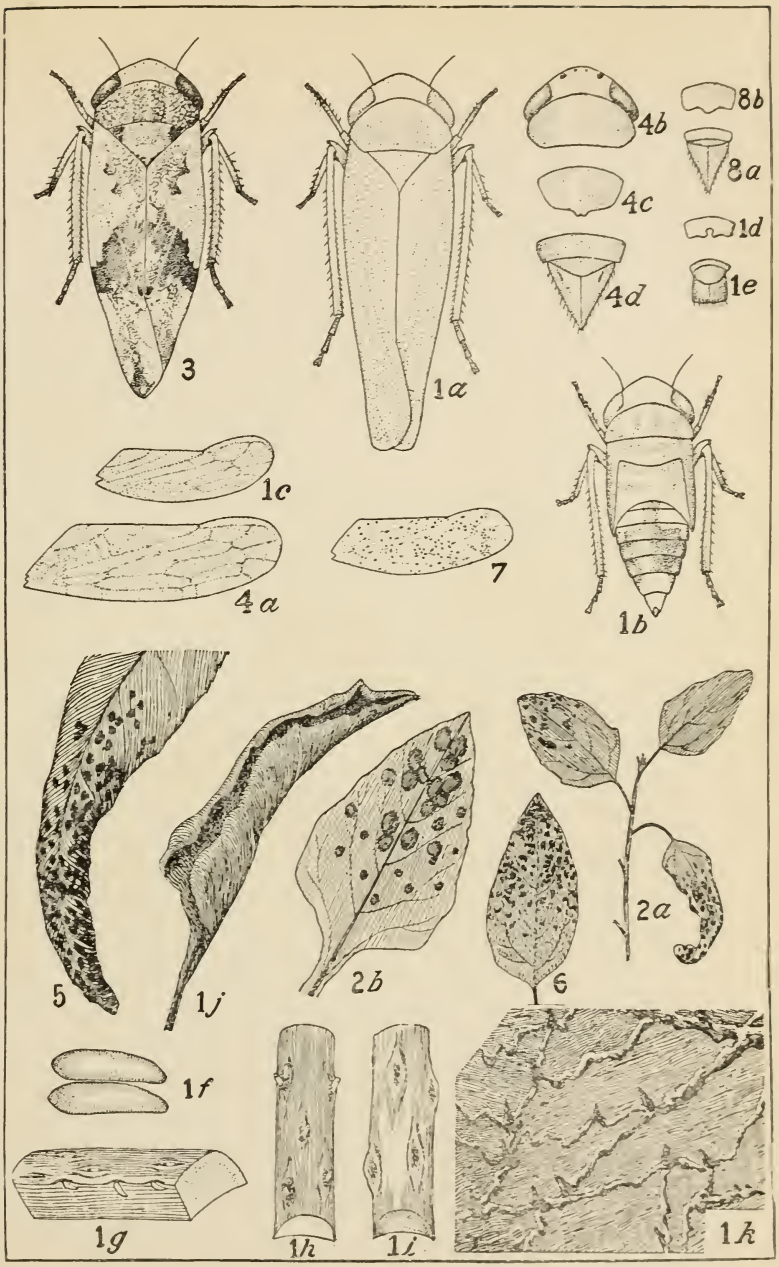
Late in June, 1905, reports began to come in to the Utah experiment station of the appearance of an insect in the beet fields of the southern and central portions of the State, and on July 8 the writer, in company with Mr. George Austin, visited the fields around Lehi and there found the beet leafhoppers, associated with smaller numbers of false chinch bugs (Nysius) and leafhoppers of the genus Agallia, causing serious damage to the young plants, especially in the late-planted fields.

From the size of the beets and the number of the beet leafhoppers present when first examined in 1905, the prediction was made that the insects would not be able seriously to retard the further growth of the beets. This prediction was based on the ordinary amount of damage done by insects of sucking habits. That the number of insects found would be able to injure or even seriously retard a very young beet was recognized, but that the same number could have any appreciable effect on large beets was contrary to all expectations based on a knowledge of similar attacks by Nysius, Agallia, and other sucking insects.

The trouble soon afterwards appeared in the Cache Valley, Utah, and was under observation there throughout the remainder of the season, while several trips were made to various parts of the State. Wherever it appeared it gradually grew worse, and although the year 1905 started with everything favorable in the early season, the Utah beet crop fell below the average about 75,000 tons. This, however, did not anywhere represent the entire loss, as both sugar content and purity of the beets harvested fell far below the average, entailing further loss to the sugar companies and bringing the total to more than half a million dollars.

In Sanpete and Sevier counties, in the southern part of Utah, a large part of the acreage was abandoned early in the season, while the rest barely paid the expense of harvesting. In Utah County the crop varied from a total loss on a few late fields to a full crop, with an average of more than a half crop harvested. In the Cache Valley, in the northern part of the State, the loss was about one-third in tonnage, and in Weber and Boxelder counties less than that.

In 1906 a very small number of leafhoppers appeared, and, as the season was cool, even where they were most abundant little damage was done. A careful study was made of the life history and distribution of the species, and a number of tests were made of its injury to the beets.



LEAFHOPPERS (EUTETTIX SPP.) AND THEIR WORK.

Fig. 1.—*Eutettix tenella:* *a*, Adult; *b*, nymph; *c*, wing; *d*, *e*, genitalia; *f*, eggs (greatly enlarged); *g*, section of beet stem, showing fresh eggs in place; *h*, same, showing eggs ready to hatch; *i*, old egg-scars on beet stems; *j*, small leaf of sugar beet, showing characteristic "curly-leaf" condition; *k*, enlarged section of back of an extreme case of "curly-leaf," showing "warty" condition of veins. Fig. 2.—*Eutettix strobi:* *a*, Work of nymphs on lambsquarters; *b*, work of nymphs on sugar beet. Fig. 3.—*Eutettix scitula:* Adult. Fig. 4.—*Eutettix clavirida:* *a*, Wing; *b*, head and pronotum; *c*, *d*, genitalia. Fig. 5.—*Eutettix nigridorsum:* Work of nymphs on leaf of Helianthus. Fig. 6.—*Eutettix stramineu:* Work of nymphs on leaf of another Helianthus. Fig. 7.—*Eutettix insana:* Wing. Fig. 8.—*Eutettix stricta:* *a*, *b*, Genitalia. (Author's illustrations.)

THE BEET LEAFHOPPER.

(*Eutettix tenella* Baker.)

DESCRIPTIVE.

The adult (Pl. I, fig. 1, *a*) is a small, pale yellowish-green species, little larger than an Empoasca or Typhlocyba, with which it might easily be confused in the field were it not for the stouter build and greater activity. When fresh or when flying this leafhopper appears almost white, and for this reason it has often been called the "white fly." (Wing, Pl. I, fig. 1, *c*; genitalia, Pl. I, fig. 1, *d*, *e*.)

The eggs (Pl. I, fig. 1, *f*) are white, elongate, slightly curved and tapering at one end, and are thrust into the leaf stem in a slightly downward direction. At first they are scarcely visible (Pl. I, fig. 1, *g*), but as the stem grows they are pushed out with the opening up of the injured spot until at hatching time they are often half free (Pl. I, fig. 1, *h*). After the eggs hatch, the egg scars continue to enlarge and remain throughout the season as irregular, elongate, crater-like swellings (Pl. I, fig. 1, *i*). The eggs are deposited on all parts of the leaf stem, usually one in a place. In the cages they were often placed close together, very likely in this case by different insects, however, and a number were inserted into the midrib and secondary veinlets of the leaf and a few into the leaf margin near the base.

The nymphs (Pl. I, fig. 1, *b*) are very active, pale creamy white or variously colored forms. The commonest form is pale creamy in color with a brown saddle on the middle of the abdomen and various mottlings on the prothorax and wing-pads. Some have the same pattern with a reddish ground color, more are creamy yellow, and occasionally one is seen with a broad and somewhat irregular dark stripe down the back. When small the nymphs will be found most commonly down in the unfolding leaves at the center of the beet, but as they grow older they spread out over the plant.

FOOD PLANTS.

The original food plant of this species is still in doubt. In the spring it was found on greasewood (Sarcobatus), sea-blite (Dondia), several species of Atriplex, Russian thistle, and rarely on other plants of these two families occurring on the waste land. As these places dried up, most of the leafhoppers went to the sugar beets in the areas under observation. In one case, however, the species was found in some numbers on greasewood during egg-laying time, which would suggest this plant as its original host. Its known distribution is all within the area in which this plant is abundant.

DISTRIBUTION.

This leafhopper is apparently a native of the southwestern part of the United States. It has been collected from about the region of Denver, Colo., south along the edge of the mountains, through New Mexico, and west through Arizona, Utah, and southern Idaho to the coast in California and Oregon. Though confined to the mountain region, its distribution is restricted to the lower levels, and it is never taken on the mountains themselves. From this region it has not spread very far up to the present time. It was taken at Fort Collins and Lamar, Colo., in 1901—in one case 100 miles north of its known habitat, on wild plants, and in the other an equal distance east, but was rare in both situations. In Utah it has spread to the northern line of the State and into Idaho as far as that particular beet area has been extended, while it has not as yet been taken from the wild plants north of Ogden, Utah.

LIFE-HISTORY STUDIES.

Search was made for this species as soon as the growing season commenced in the spring of 1906, but no specimens were discovered in the Cache Valley, Utah, up to the time the beets came up. A trip to Sevier County, Utah, at the time the very earliest beets were just showing (April 22) failed to disclose a single individual, either in the beet fields or in waste places or hedgerows adjacent to the beet-growing districts. The first specimens discovered this season were found at Thompsons, Utah, May 3, feeding on Russian thistle, and a few days later the insect was found on the same plant and on an annual saltbush (Atriplex) at Grand Junction, Colo.

Beet fields were examined at Grand Junction, Colo., May 8, and in Utah at Lehi, May 9; Smithfield, May 12; Garland, May 13; Lehi, May 17; Corinne and Penrose, May 22; and Provo and Lehi, June 1, without finding a single leafhopper on any of them. The beets were not up at Lehi on May 9, nor at Smithfield, but the fields were examined carefully, especially where weeds were beginning to appear. Fields at Logan, Utah, were under observation during all this time and up to July 1, but no leafhoppers were found.

RECORD AT LEHI, UTAH.

On June 21 a field was examined at Lehi in which there was an average of one or two leafhoppers to a beet. They were all adults and two-thirds of them females. The beets in this field were from 6 to 10 inches across, and no sign of injury was observed. On examining the other fields in the valley a very much smaller number of leafhoppers was found. Some fields had one individual to 10 beets,

while some had none at all. The average would not have been more than one leafhopper to 25 beets. They were most numerous on the higher, drier fields, and on the early beets. Two patches of very late beets close to the first one visited had no leafhoppers at this time.

Eight females from this field were dissected, and fully developed eggs were found in each one, 9 in one, 7 in another, and from 2 to 4 in each one of the others. Only large eggs could be seen with the lens used, and probably some of these were crushed while being removed. The fact that all females had fully developed eggs and that there were more females than males indicated that these adults had been out a long time and were not new ones of a brood that had just flown in from surrounding wild land.

On June 29 a few were found in the late beets, but no nymphs were found anywhere.

July 10 the adults were present in about the same numbers as before, the females still containing eggs, and a few very small nymphs were found.

July 23 the adults were slightly less numerous, and the nymphs from small to one-third grown and quite abundant. A few of them were nearly grown, but no fresh males could be found. More nymphs were found on the early beets, more "curly leaf" on the late ones.

August 3 the nymphs were mostly about two-thirds grown, some were small, and some full-grown. Large numbers of adults of the new brood were out, about half of the leafhoppers being adult at this time.

August 14 the adults were abundant. The leafhoppers were nearly all adults or large nymphs, but a few small nymphs were still to be found.

On August 29 the insects were mostly adult, males being still in the majority, but there was still quite a number of full-grown nymphs. Many females were dissected and a few found that had from 4 to 7 large eggs, but the rest had no sign of any. These few were probably the last remnant of the over-wintered brood of females.

September 12 the adults were still common and more males than females were taken by sweeping. Large nymphs were still present in small numbers. Ten females were dissected, but no eggs found, and the abdomens were all small. Evidently there was to be no egg laying for some time, probably not that season.

Note.—The season opened unusually late at Lehi in 1906, and these dates would be from one to two weeks late for an ordinary season.

RECORD AT MONROE, UTAH.

In Monroe, Sevier County, the season opened early, and the beets were nearly all planted in April. An examination April 22, as mentioned above, failed to discover a single leafhopper.

On June 26, on a second visit, nearly all the beets were in fine shape, with leaves touching in the rows, and only lacking a few inches of touching across rows. The leafhoppers were present in every patch, both adults and very small nymphs, and occasionally a larger nymph was seen. Mr. Fred Gould, field superintendent, said that he had observed the adults for some time. There were more leafhoppers on the older patches than on the late planted ones, indicating that they had migrated in before the younger beets were far enough advanced to attract them.

On July 25 the leafhoppers had increased in numbers, averaging from 10 to 20 to a beet on the earlier patches. Adult males were common, showing that the nymphs had commenced to change to adults again. All stages of nymphs were still common, however.

On September 14 the numbers of leafhoppers were beginning to decrease. Several countings gave an average of 7 males to 5 females and 5 large nymphs. The dissection of a number of females showed no eggs developed as yet, and there seemed little doubt that they would hibernate.

OTHER RECORDS IN UTAH.

A field belonging to a Mr. Irons at Moroni, Sanpete County, was visited June 27, and an average of one leafhopper to every two beets was found. Mr. Irons, who is a very careful observer, said that they had been there for some time. A careful search was made for the nymphs, but none was found. This was by far the worst infested field in the county, the average being less than one insect to ten beets.

July 26 adults and nymphs were about equally common, and few of either.

In the Cache Valley and the rest of the northern end of the State the leafhoppers did not appear in sufficient numbers to enable one to make any life-history notes. On this account all cage experiments were transferred to Lehi.

CAGE EXPERIMENTS, LEHI, UTAH.

The field observations on life history were all checked by cage experiments (Pl. IV, figs. 2, 3). Cages 1 to 3 were failures, through the adults escaping from the material used. Later a very fine silk scrim was used and proved satisfactory for the life-history work, but was too closely meshed to obtain normal temperature and moisture conditions inside. All cages were run in pairs on similar beets, one with insects and one without, as a check on the injury to the beet.

Cages 4 and 5 (glass globes upon beets about 8 inches in diameter).—On July 10, 16 adult leafhoppers, 12 of which were females, were introduced into cage 4. Previous dissections had shown that all females were bearing eggs, and the presence of a very few small nymphs in the field proved that the earliest ones began depositing eggs some time before. It was therefore expected that some of the females introduced would begin depositing at once.

On July 23 these cages were examined, and in the one containing the leafhoppers the stems were found to be fairly covered with egg scars. Two of the stems were removed and preserved, and found to contain 161 eggs—not more than one-sixth of the total number present. A number of females were seen in the cage, but no nymphs.

July 27 the stems showed still more egg scars, and there was quite a number of small nymphs that had apparently been out several days. The insects had been in the cage only seventeen days, so these eggs must have hatched within thirteen to fifteen days from the time of laying, under the conditions found in the cage. Another stem was removed and preserved, and the rest left as before.

On August 3 another stem was removed. The eggs had almost all hatched by this time. Some had dried up and a few were found just ready to hatch. A few were sticking out of the stalk and looked quite fresh, but were probably infertile. Some of the leaves had wilted and died, and the remainder were literally alive with small to half-grown nymphs, together with a few adults, no doubt the remaining parents.

These half-grown nymphs were no doubt those hatched between July 23 and 27, and would thus be between eight and eleven days old, roughly indicating a nymphal period of between sixteen and twenty-two days under these conditions.

On August 14 this cage was visited again, and the beet found dead and dry. From appearances it had been dead several days. The few leafhoppers that survived were adults and large nymphs. They were so few in number that it was impossible to tell whether they were the surviving parents or a new generation, so they were released.

Cages 6 and 7 (silk scrim 2 feet square).—On July 23, 18 nymphs varying between one-third and two-thirds grown were introduced into cage 6. These were intended to represent the larger ones found in the field at that date.

On July 27 no adults could be seen.

On August 3 most of the nymphs had changed to adults. This period of eleven days was, then, more than one-third and slightly less than two-thirds of the nymphal period. This gives about the same result as the test in cage 4.

Cages 8 and 9 (silk scrim with glass top).—On August 3, 40 leafhoppers were introduced into cage 8; of these 23 were females,

apparently all fresh, 10 were males, and 7 were large nymphs, the aim being to get as many of the earliest ones of the maturing brood as possible without introducing any belated ones of the parent brood. By this method it was hoped to get the succeeding brood, if there was to be one, as soon in the cages as it appeared in the field, and thus establish a minimum time between broods.

On August 14 this cage was examined, and all leafhoppers seen were adults. There were no signs of egg scars or of damage.

On August 30 but few leafhoppers could be seen, and no egg scars or damage.

On September 12 the leafhoppers were almost all gone, and no eggs had been laid, either in the cage or field, and dissection showed that the females had no visible eggs in the abdomen up to date. It was thought at this time that the adults would lay eggs in the fall and then die. Accordingly a new lot was started, as shown below.

Cages 10 and 11 (large lantern globes).—On August 30, 30 leafhoppers were introduced into No. 10, of which 12 were females. In No. 11 one female and several males were introduced. On September 12 no egg scars could be found in either cage.

Cages 13 and 14 (silk scrim with a glass top).—On September 12, 20 leafhoppers, nearly all of which were females, were placed in cage 13.

On October 20 the field of beets was harvested. The cages were removed and the beets labeled and sent on for examination. Each leaf and stem, and even the parts of the beet itself protruding from the ground, were examined carefully, but no sign of any egg scars could be found on these beets or on those from the previous cages. Many of the leafhoppers were alive at the time the cages were removed, and there seems to be no doubt that they must hibernate as adults.

SUMMARY OF LIFE HISTORY.

By the time the beets were thinned the leafhoppers began to appear in the fields and by the middle of June were well distributed. They gradually increased in numbers for some time after this. Egg laying began at Lehi, Utah, late in June and continued until late in August, each female depositing about 80 eggs, the period of deposition extending through several weeks, the greater number of the eggs, however, being deposited in the ten days preceding the middle of July. The nymphs appeared in small numbers by July 10, and were still to be found in small numbers in September. A great majority of them emerged from the eggs the last ten days in July and changed to adults some twenty days later. The first adults appeared from these nymphs the last of July and continued to increase in number through August. The egg stage in the cage experiments was between thirteen and fifteen days; the larval stage between sixteen and twenty-two days.

ECONOMIC RELATIONS.

The first fact observed in 1905 was that different fields were affected very differently, and much time was spent in studying conditions in an attempt to discover just what combination of factors was necessary to produce the "curly-leaf," so fatal to the beets. Even in the worst fields examined there would be here and there a beet that was apparently untouched and growing as usual, while in the best fields only here and there could an affected one be found.

As a result of the season's observations there seemed to be little question that the "curly-leaf" condition was the result of the attack of the leafhoppers combined with the effect of a very hot, early season.

In many places it was noticed that along the edges of the fields where the beets had any shade—such as would be furnished by a hedgerow, or even by a vigorous stand of sweet clover on a ditch bank—there would be a marked difference for the first few rows. In Sevier County, where many of even the early-planted fields were abandoned and where the rest averaged from 2 to 4 tons per acre, one field was seen that did not show much damage and yielded 12 tons per acre. This field had a block of tall poplar trees on the south and a row of equally tall ones on the west side. In other places it was observed that the fields that were the weediest had better beets than those that had been well cultivated. Under ordinary conditions the results in all these cases would have been just the reverse, and the only explanation that seemed plausible was that the shade of the trees and of the weeds kept the ground from becoming quite so hot and thus allowed the beets to overcome the effects of the leafhoppers. In ordinary practice the beets are not irrigated until they have made considerable growth; thus the taproot is forced to descend for water, and a long, symmetrical beet results, while if watered too soon the beets are short and sprangly. In one place, in 1905, it was found that the water had escaped from a ditch and irrigated one corner of a field much earlier than it had been applied to the rest, and this corner was the only place that was not seriously affected with the "curly-leaf." In another place the water supply failed just as they started to irrigate the field, and the remainder was not irrigated until a week later. The difference in the amount of "curly-leaf" on these beets showed plainly to the end of the season just how far the early water reached. At first these differences were attributed to the effect of the early water on the beet itself, but on further investigation a number of fields was found where subirrigation was depended upon entirely and where, ordinarily, fine beets were raised. In these fields the taproots of the beets were found to extend into a stratum of saturated soil and yet the beets were badly affected and continued to grow

worse throughout the season. The only explanation found for that condition was that, while the beet had plenty of water, still the top soil was dry and dusty, and the ground was as hot as in an ordinary field, while in the fields that were irrigated early the evaporation from the moist surface kept the temperature down until the beets were large enough to shade the ground. This would also explain the fact that everywhere in the State, except in Sevier County, the late beets were affected much worse than the early ones. In other portions of the State the early beets were large enough to shade the ground in the rows by the time the hot weather and leafhoppers appeared. In Sevier County, on the other hand, the hot, dry weather came on earlier and the leafhoppers were so much more numerous that even the earliest beets could not withstand their attack when exposed to the full force of the sun.

The unusual numbers of the beet leafhopper were apparently largely the result of a winter and spring favorable for the preservation of insect life, as almost all injurious insects were present in increased numbers during that season (1905). The leafhoppers had, however, evidently been increasing for several years and had even before this reached destructive numbers in Sevier County, as the beet growers there had been suffering increasingly from what they called "blight" for two years previous to this, and this increase in the number of insects, followed by a winter favorable to their survival, resulted in the outbreak of 1905.

The leafhoppers were present in every field examined in Utah that season, and occurred in the greatest abundance in the areas in which the "curly-leaf" was worst. The average number of adults of the over-wintered brood to a beet varied from 3 or 4 up to 10 or 15, and probably even more than that in Sevier County, judging from the number found there later. No serious damage was done where there were only the smaller numbers, and even where the damage was worst it seemed to depend more upon how early they appeared and the temperature and moisture of the locality at that time than on the actual number above an average of possibly 5 or 6 to a beet. In 1906 they appeared in very small numbers. The field at Lehi, Utah, where the experiments were conducted, was by far the worst found, and here they averaged only about 1 or 2 to a beet, while the average of the valley would not have been more than 1 to every ten or fifteen beets, and the average of the State was even less.

A field in Boxelder County, Utah, was examined in August, 1905, in which the leafhoppers had recently appeared in large numbers, averaging 100 or even 200 in some places to the beet. The beets were large enough then to shade the ground, and the field was well irrigated from that time on. Almost no curling of the leaves could be

found in this field, and in the fall the yield was nearly up to the average. This was the only field examined in which the leafhoppers did not appear until after the adults had hatched out. On the other hand, many fields were examined in which the leafhoppers had been present early in the season but had almost disappeared after the nymphs had matured, and yet in these fields the curling continued to develop throughout the season and the beets grew worse instead of recovering.

Spraying with kerosene emulsion was tried on a field in the Cache Valley, Utah, in 1905. This field contained numerous adults and nymphs in all stages. Four nozzles were used, each one set about 18 inches above the row and pointing obliquely down and forward, and just in front of them a bar drew the beet tops over and caused the leafhoppers to jump just as the spray struck them. An emulsion diluted with 15 parts of water had little effect on the adults, and only killed a few of the smaller nymphs. Most of the nymphs would kick about on the ground and some would become quite still, but a little later most of them would recover and hop away. An emulsion diluted with 8 parts of water produced the same effect on the adults that the weaker dilution did upon the nymphs, and killed the majority of the nymphs that it struck. Many of the latter would, however, escape the spray on account of the broad leaves of the beet, and the results were not considered entirely satisfactory.

In the cage experiments it was expected that the number of leafhoppers necessary to cause "curly-leaf" on different-sized beets would be ascertained, but owing to the fineness of the gauze necessary to hold them the temperature and moisture could not be controlled and no "curly-leaf" was produced.[a] The damp conditions of the cages also made it difficult to keep the insects for any length of time.

In one experiment 16 leafhoppers, 12 of which were females ready to deposit eggs, were placed on a beet with a top 8 inches in diameter

[a] This manuscript was originally prepared and submitted at the close of the season of 1906. Some revision was made to include the important facts of the work of 1907, but the main discussions, including the above paragraph, were written in 1906. Since that writing "curly-leaf" has appeared in cages arranged by Prof. E. G. Titus in joint investigations with the writer. Mr. H. B. Shaw, assistant to Dr. C. O. Townsend, in charge of Sugar Beet Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, has also succeeded in producing "curly-leaf" under experimental conditions. He writes me under date of October 23, 1908, that curly top or "curly-leaf" appeared in the cages on the experimental plat at Garland, Utah, in which he introduced the beet leafhoppers, and that later he sent a number of leafhoppers to the office of Sugar Beet Investigations, Bureau of Plant Industry, where 6 of them were placed in a cage with 11 young beets, 9 of which showed distinct symptoms of "curly-leaf" within five weeks after the insects were introduced.

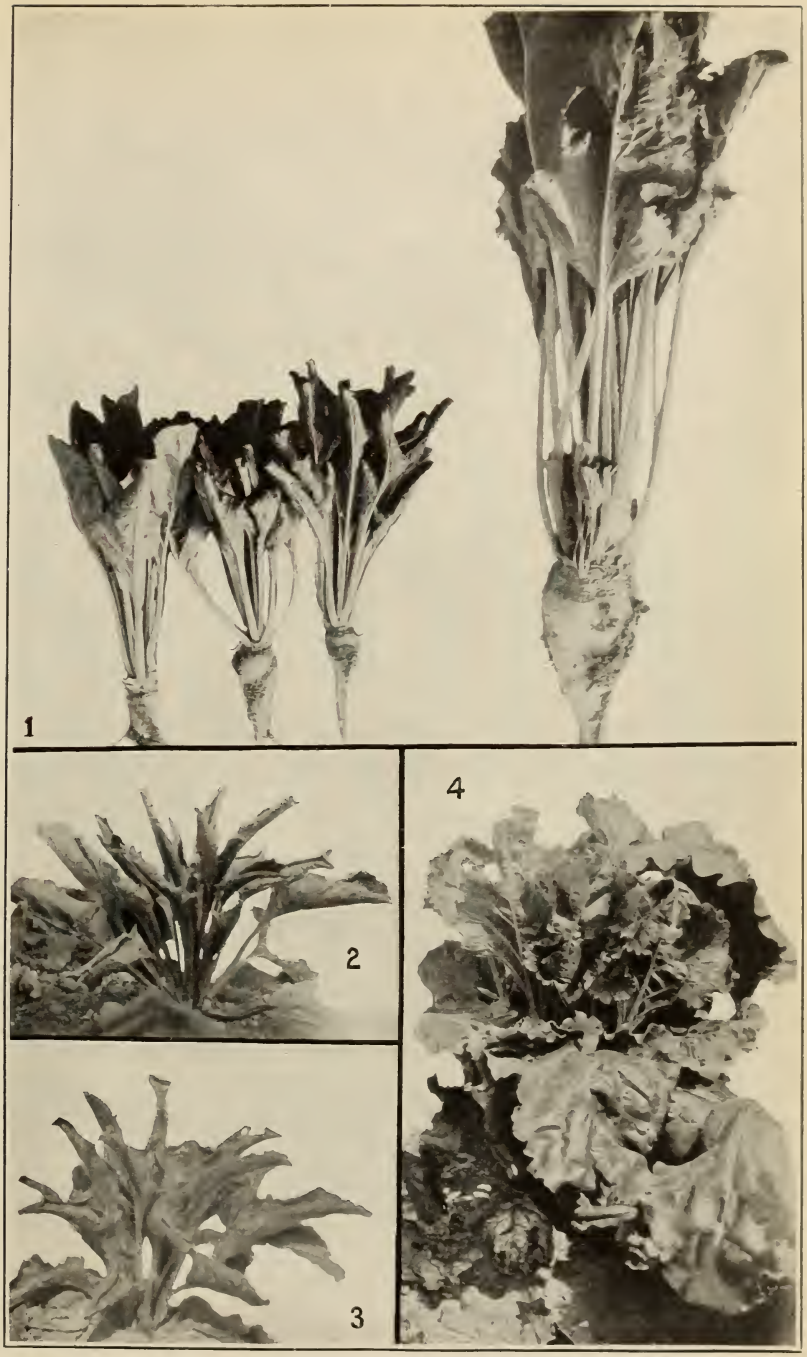
and consisting of a dozen or more leaves. Over another beet of the same size a check cage was placed. Seventeen days later the eggs had just begun to hatch, and already the beet in the cage without any hoppers was nearly twice the size of the first one. The beet on which were the leafhoppers continued to grow for a week or more, then practically stood still, and on the seventeenth day it was apparently smaller than when examined five days before. Seven days later a large number of nymphs had hatched out, the outer leaves were dead, and the rest looking sickly; ten days later than this the cage was examined again and the beet was dead and dry, while the beet in the check cage had again doubled in size. Twelve leafhoppers and their eggs stopped the growth of a beet in less than two weeks, and they, together with their progeny, killed it in less than two weeks more. The same number of adult specimens of Agallia, Nysius, or Empoasca would scarcely have made an impression on a beet of that size.

CHARACTERISTICS OF "CURLY-LEAF."

The first symptom of "curly-leaf" or "blight" of the beet is a thickening of all the smaller veinlets of the leaf, giving it a roughened appearance on the underside. This is followed by a curling of the edge (Pl. III, fig. 1) and a final rolling up of the leaf (Pl. I, fig. 1, *j*; Pl. II, figs. 2, 3; Pl. III, fig. 2), the upper surface always being rolled in. As this progresses the small veinlets grow still larger and more irregular, knotlike swellings appear at frequent intervals (Pl. III, fig. 2), and in extreme cases little nipplelike swellings appear, extending to a height of nearly one-fourth of an inch (Pl. I, fig. 1, *k*). This will be noticed first upon a medium-sized leaf, gradually spreading to the younger ones, while at the same time the beet almost stops growing and a large number of fibrous roots are sent out (Pl. II, fig. 1). These roots are not confined to two irregular lines as in a healthy beet. The beet often continues in this way throughout the season, in bad cases it shrivels and dies, while in a few instances there is a partial recovery and a new set of leaves, though the sugar content remains very low.

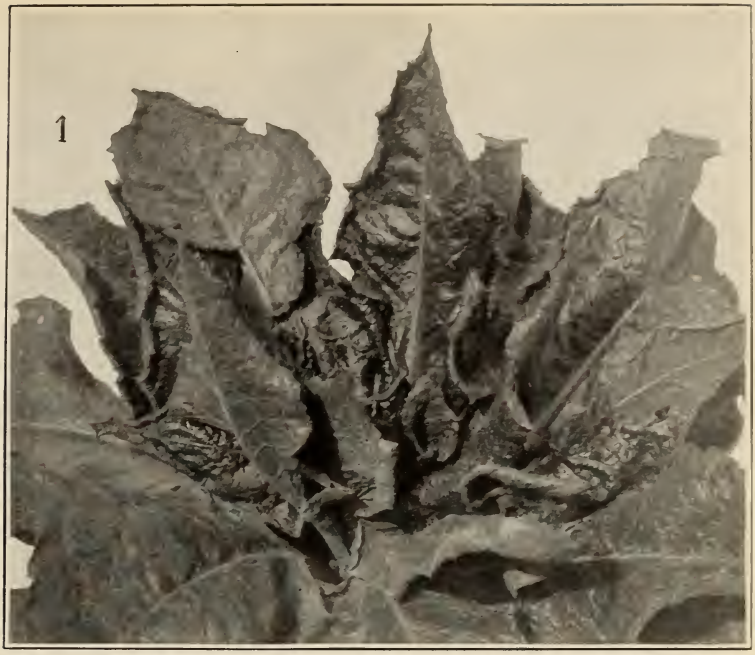
Many of the species of this genus of leafhoppers produce a discoloration or distortion of the leaves of their food plant. This appears to be of the same nature as the work of the gall-forming species, and is a process little understood. The wrinkling and folding of the leaves by some of the species is very similar in appearance to the work of some gall-forming aphides. Some species also produce a change in color similar to that produced in many galls.

In the case of *Eutettix strobi* (Pl. I, fig. 2 *a*, *b*) and *E. scitula* on the Chenopodium or on the sugar beet and of *E. nigridorsum* and *E. straminea* (Pl. I, fig. 6) on the Helianthus the discoloration appears as



WORK OF EUTETTIX TENELLA ON SUGAR BEET.

Fig. 1.—Three "curly-leaf" beets, the result of attack by *Eutettix tenella*, and one normal beet from the same field, showing difference in size. Figs. 2, 3.—"Curly-leaf" beets as seen in the field. Fig. 4.—Normal beets from same field. (Original.)



WORK OF EUTETTIX TENELLA ON SUGAR BEET.

Fig. 1.—A large beet becoming "curly." Fig. 2.—Back of a leaf affected by "curly-leaf," showing "warty" condition and curled edges. (Original.)

soon as the little nymphs begin to feed, and this is soon followed by the distortion of the leaf in a certain definite way in each case. That this is not caused by the mechanical injury of the puncture or due alone to the loss of sap seems to be abundantly proved by the fact that the Chenopodium is often attacked by other sucking insects in much larger numbers without producing either the red pigment or the gall-like distortion. The fact that a certain characteristic color and appearance are always produced by a given species, no matter whether on a Chenopodium or on a sugar beet, and that the color and form vary for the different species of the same genus even when working on the same plant, would indicate that there is some definite agency back of it all. It has also been noticed that in all this group the greatest amount of damage is done in hot, dry situations.

Whether or not the "curly-leaf" condition is entirely the result of the change in the beet caused by the attack of the beet leafhopper is still an open question, but that there is some relationship between the leafhopper attack and the "curly-leaf" does not seem to admit of a doubt in the light of the facts brought out in the investigations. The amount of damage in a given valley was directly proportional to the number of leafhoppers present, the injury appeared only after the appearance of the leafhoppers, and the "curly-leaf" condition is known to occur only on beets growing within the range of this insect.

Attention was not called to the damage early enough in 1905 to ascertain whether or not the "curly-leaf" appeared before the first appearance of the nymphs. At Lehi, Utah, the "curly-leaf" appeared very soon after the first nymphs. In the Cache Valley, Utah, the nymphs were common by the time the first curling was noticed. In 1906 very careful watch was kept in all parts of the State for the very first sign of leaf-curl, and in no case did it appear (except on the mother beets) until after the nymphs began to hatch out. In fact, in almost every case examined the cast skins of nymphs could be found on the back of curled leaves, while on healthy beets these were very seldom found. In all observations of both years more leafhoppers were found on the curled beets than on others. At first this was thought to show a gregarious habit in the adult, but it may be due to the fact that a given female lays most of her eggs on a single plant and the nymphs tend to remain there. In *Eutettix strobi* and the other leaf-curling forms, where the nymphs are brightly colored and depend on their discolored spots for protection, it is not unusual for a given nymph to pass its whole life on a single leaf, or on two or three adjoining ones; in most cases but a single nymph will be found on a plant, and sometimes the adult and the nymphal skin of each stage may be found under a single leaf. It is very likely that the same habit persists in *Eutettix tenella* and that this fact, in part at

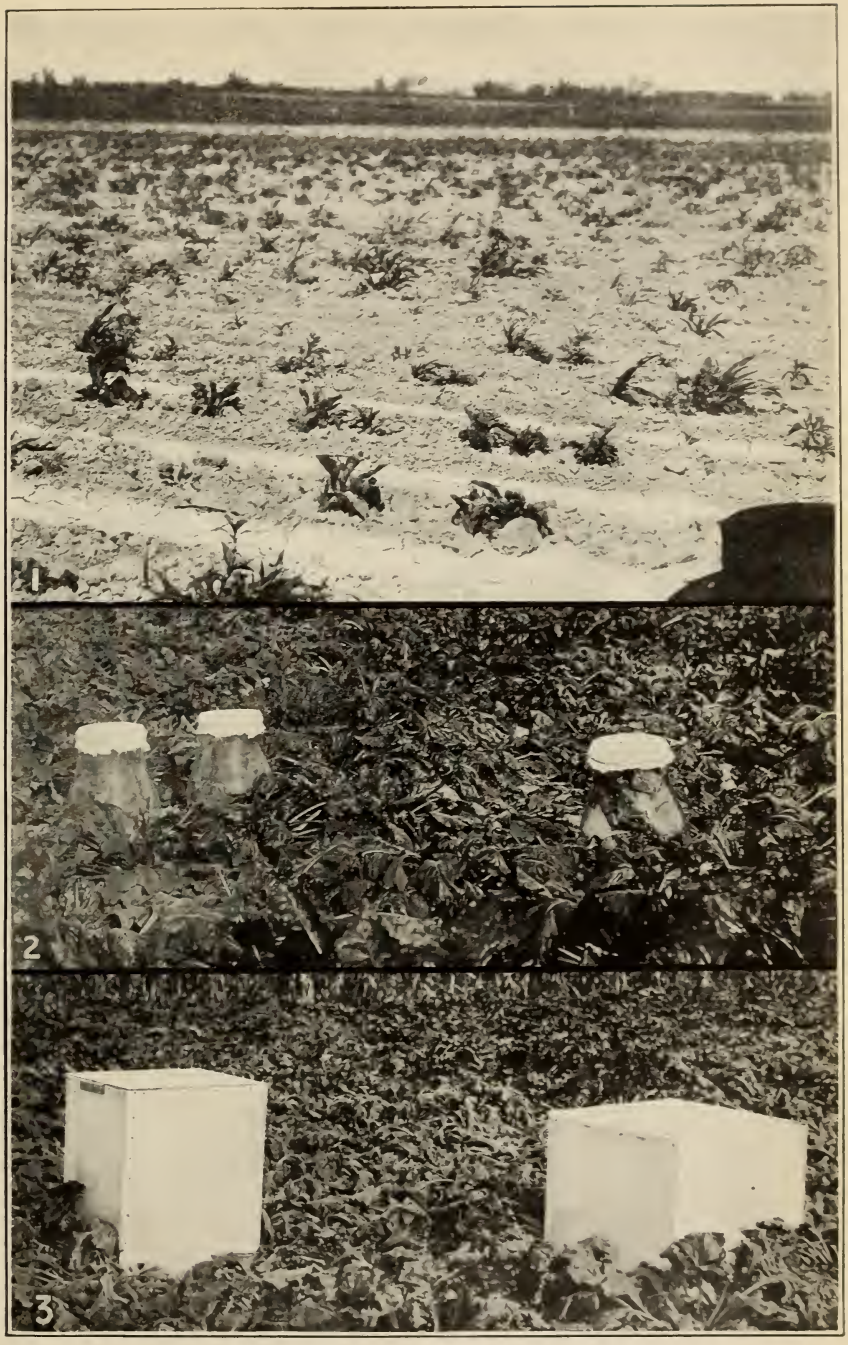
least, accounts for one beet being badly affected while the adjacent ones are unharmed. In the case of *Eutettix strobi* and its allies, where most of the leaves of a small plant are affected by the distortion, the plant usually shrivels up and dies, but where only one or two leaves on a large plant are distorted the plant does not appear to be affected at all, and in no case does the color appear in any of the new leaves. In several cases small beets have been seen in which every leaf has been deformed by the work of *strobi*, and they had apparently stopped growing.

In the case of the "curly-leaf," however, the abnormal condition apparently spreads from leaf to leaf until finally the whole plant is affected, even though the leafhoppers may have disappeared before the process is complete. This was abundantly demonstrated by the mother beets set out in the spring of 1906. These beets were selected from the best-looking beets of 1905, and would naturally have been ones that showed little or no effect of the "curly-leaf" the season before. In every case observed the first leaves sent up by these beets were as curly as the average of the year before, and most of them formed stunted lettucelike heads, and later withered and died. Some, however, survived through the season, and a few sent up stunted blossom stalks, but as a seed crop they were an entire failure. This curling took place before any leafhoppers were found in the beets, and in rows adjoining young beets that were not at all affected and did not become affected during the season. This would indicate that the agency, whatever it may be, that causes "curly-leaf" remained in the beet itself over winter and was transmitted to the first leaves in the spring.

In early September, 1907, the sugar-beet region around Spreckels, Cal., was visited by the writer and a number of cases of what was commonly called "blight" or "curly-leaf" were examined. These, however, proved to be quite different in character from the "curly-leaf" condition caused by *Eutettix tenella*. The leaves of the beet were found to be covered with pale spots, the edges were turned down instead of up, and the whole appearance was quite different. A careful search was made over many acres for specimens of *tenella*, but none was found; instead a species of Empoasca was always found associated with this appearance of the beets. The matter will be discussed further in connection with that species (p. 51).

OTHER RECORDS.

Prof. E. G. Titus reports that on a trip through the sugar-beet regions of the West in September, 1904, he found *Eutettix tenella* at La Grande and Echo, Oreg. At La Grande little damage was done, while at Echo one field of 10 acres was so seriously injured by what



WORK OF EUTETTIX TENELLA ON SUGAR BEET.

Fig. 1.—A field of beets destroyed by "curly-leaf." Figs. 2, 3.—Cages used in the life-history experiments. (Original.)

was then called "blight" that it was not harvested. Many of the beets had died and the rest were small and stunted, while the leafhoppers could be swept up in numbers.

In California "curly-leaf" conditions were seen by Professor Titus at Oxnard and Spreckels and reported to be quite serious on the higher lands back of Salinas. Whether this was the true "curly-leaf" or the type found there this year was not determined.

In August, 1907, another trip was made by him through the same territory and a few specimens of *Eutettix tenella* taken at Payette, Idaho. Little damage was being done that season, but field men reported considerable loss in 1905 in both Payette and Blackfoot, Idaho. A few *E. tenella* were taken at Union, Oreg., and Echo, Oreg., in August, 1907, only slight damage showing in either place. Large nymphs were taken with the adults.

In California a number of places were visited by Professor Titus in August, 1907, but no specimens of Eutettix taken. In September another trip through the California districts was made, and a few specimens of *E. tenella* were taken at Chino on the 13th. No very definite cases of "curly-leaf" were noticed.

ECONOMIC SUMMARY AND PROPOSED REMEDIES.

The "curly-leaf" condition or "blight" of the sugar beet, as it occurs in Utah and the surrounding region, appears soon after an attack of the beet leafhopper (*Eutettix tenella* Baker). Its severity is conditional upon the number of insects present, upon the time of their appearance, upon the size of the beets, and upon the temperature of the surface soil, together with the temperature and moisture of the surrounding air.

More should be known about the places of hibernation and early spring history of this insect. It could not be found in the rubbish around the fields in early spring, and only a few specimens were found in waste places up to the time they appeared on the beets. When once the place where the greater number of them pass the winter is discovered, it may be possible to destroy them there or on their spring food plants before they migrate to the beets. After they have appeared on the beets it will be necessary to be very prompt in the matter of remedies if the injury is to be prevented. A thorough spraying with kerosene emulsion at a strength of 1 part of the stock solution[a] to 5 parts of water would destroy most of the insects that it hit, and by using a drag in front of the nozzles to turn the leaves over and cause the insects to jump, most of them could be reached. Where the insects

[a] For directions regarding the preparation and use of kerosene emulsion see Farmers' Bulletin 127, U. S. Dept. of Agriculture, pp. 20–21, and Circular 80, Bureau of Entomology.

were coming in in numbers this spray would need to be followed by a second one 10 days later.

Several mechanical devices have been used to catch different leafhoppers, and no doubt several of these could be used against this insect with advantage. The tar pan, or "hopper-dozer," drawn over the beets two or three times in the first few weeks would capture a large number of them. The females, before the eggs are laid, are quite heavy and do not jump or fly as readily as the males and would be easily caught. A modified form of this machine, consisting of a couple of tarred wings to be drawn along on each side of a row of beets, while a drag agitated the tops and caused the insects to fly, would probably capture more than the simpler tar-pan.

If the insects appeared while the beets were quite small, they could be largely destroyed by rolling when the weather was cold or damp and the insects sluggish.

A number of preventive measures may be used to assist the beets in withstanding the attack of the leafhoppers. In some sections early planting will produce beets large enough to shade the ground by the time the beet leafhoppers appear, and thus reduce the temperature below the danger line. In a few places, like the Grand Junction district in Colorado and Sevier County in Utah, early planting alone would not avail, as the insects appear soon after the earliest beets come through the ground. For such sections early and frequent irrigations would assist in keeping the ground cool until the beets grew large enough to shade it and thus take care of themselves.

All preventive measures will depend for success upon some method of controlling the temperature in the field so that the ground may not be hot and dry at the time the leafhoppers appear.

BIBLIOGRAPHICAL REFERENCES.

1895. Gillette, C. P., and C. F. Baker.—A preliminary list of the Hemiptera of Colorado.<Bul. 31, Colo. Agric. Exp. Sta., p. 100.
On sugar beets in Colorado. Mention as *Thamnotettix tenellus* Uhl. MSS.

1896. Baker, C. F.—New Hemiptera. <Psyche, Vol. VII, Suppl., p. 24.
Species described from New Mexico as *Thamnotettix tenellus* n. sp.

1900. Forbes, S. A., and C. A. Hart.—The economic entomology of the sugar beet. <Bul. 60, Ill. Agric. Exp. Sta., pp. 423, 523.
On sugar beets in Colorado. Mention as *Eutettix tenella* Bak.

1903. Chittenden, F. H.—Yearbook U. S. Dept. Agric. f. 1902, p. 730, 1903.
Mention. "Reported as injurious to sugar beet in Arizona."

1906. Howard, L. O.—Yearbook U. S. Dept. Agric. f. 1905, p. 630, 1906.
Injury in Utah. Mention as *Eutettix stricta* Ball.

1907. Ball, E. D.—Report of the entomologist. <16th Rept. Utah Agric. Exp. Sta., p. 16.
Character of injury and damages in 1905. Mention as *Eutettix tenella* Bak.

1907. Ball, E. D.—The genus Eutettix. <Proc. Davenport Acad. Sci., Vol. VII, pp. 27–94, Pls. I–IV.
A systematic and economic review of the group, with original illustrations.

OTHER LEAFHOPPERS.

Seven species of leafhoppers of the genus Eutettix besides *tenella* are known to have definite food plants related to the sugar beet, and several more, the food plant of which is not known, will probably be found to have similar habits. All of these species will no doubt be found on the sugar beet as fast as its cultivation is extended into the regions where these insects occur. The following species of Eutettix are already known to occur on the beet, and are arranged in about the order of their present importance.

Eutettix strobi Fitch.—The nymphs of *Eutettix strobi* are thickly spotted with red, giving them a strongly reddish appearance. They are found on *Chenopodium album* (Pl. I, fig. 2, *a*) and are confined strictly to the underside of the leaf. The attack produces a red discoloration and a curling of the leaf, which serves as a double protection for the insect. There are two broods in a season, the nymphs appearing in late May and early June and maturing from the middle of June into July. The adults of this brood are common from the middle of June through July. Nymphs appear again late in July, from which adults appear late in August, and more commonly in September. This species was carefully studied through the first brood in 1906. Then the area under observation was pastured and the record lost. The Colorado records agree with last year's work for the first brood, and furnish data for the second one. Prof. Herbert Osborn[a] first called attention to the red coloring of the leaves. It has been noticed many times since. This is, no doubt, the *Allygus* sp. of Bruner.[b] Forbes and Hart have mistaken the nymph for that of *Phlepsius irroratus* Say.[c] The larva of *P. irroratus*, however, is brownish and fuscous and lives on the ground. *Eutettix strobi* has been found on beets (Pl. I, fig. 2, *b*) in a number of places in Colorado and Utah, nearly all of them, however, around the margins of fields. In one place the insects had appeared on the beets when they were quite small, and had been numerous enough to deform every leaf on a number of beets and entirely stop their growth.

Eutettix scitula Ball (Pl. I, fig. 3).—*Eutettix scitula* is a white species with a brown saddle and brown pronotum. The nymphs are of a powdery pink color and live on the underside of the Chenopodium leaf in the same way that those of *Eutettix strobi* do, except that the discolorations are lighter. This species is apparently two-brooded. The first brood has been carefully worked out, but only adults have been observed in the fall. The broods appear about the same time as those of *E. strobi*. This is a western species occur-

[a] Science Vol. X, p. 166, 1887.
[b] Bul. 23, o. s., Div. Ent., U. S. Dept. Agric., p. 17, 1891.
[c] Bul. 60, Ill. Agric. Exp. Sta., p. 424, 1900.

ring in Colorado and Utah and has been found on sugar beets only at Grand Junction, Colo. The adults of the species are almost invariably found on poplar trees, and it seems probable that the eggs are deposited on twigs of the trees and that the nymphs drop to the ground to find a home on the Chenopodium. The adults of *Eutettix strobi* and *E. seminuda* are often found on trees and may have the same habit. In the case of *E. strobi* and *E. scitula*, nearly all instances of bad infestation have been near trees. In the case of *E. scitula* these have been poplars, but two of the worst instances of injury from *E. strobi* were alongside apple trees.

Eutettix seminuda Say.—*Eutettix seminuda* is a white insect with a brown saddle. It occurs from Kansas east to the Atlantic coast. The nymphs are pale, with a brown saddle on the abdomen and some brown on the thorax. Nothing is known as to their native food plant, but from the close relationship to the preceding species it is likely that it will prove to be a Chenopodium. There are two broods in a season, the first one appearing slightly earlier than in the case of *E. strobi*. *Eutettix seminuda* has been reported on beets in Illinois. It does not occur in the West, where the writer has worked on beets.

Eutettix clarivida Van Duzee (Pl. I, fig. 4, *a*, *b*, *c*, *d*).—*Eutettix clarivida* is a green species with four black points on the margin of the vertex. It occurs very commonly on the shad scale (*Atriplex confertifolia*) and on one or two other species of the same genus in the arid regions. It has been found on beets at Grand Junction, Colo. The nymphs are green, with two black spots on the vertex. The life history is not known.

Eutettix insana Ball (Pl. I, fig. 7), *E. albida* Ball, and *E. puperculata* Ball occur on different species of Atriplex in the arid regions, and may be expected to occur on the beets.

Eutettix stricta Ball (Pl. I, fig. 8, *a*, *b*) is an Arizona species and the nearest relative of *E. tenella* that we know. There is probably more danger from this than from any other species of the group, if the sugar beet should be introduced within its range.

All the species of Agallia in a given section will be found attacking the sugar beet more or less. Several of the species seem to be almost omnivorous in food habits, but where they do show a preference it is for the relatives of the beet. For two of the species (*cinerea* and *bigeloviæ*) a definite food plant is known, and in both cases they are close relatives of the beet. The species of Agallia are divided into two groups, based on structural and life-history characters. In one group, which includes *sanguinolenta*, *uhleri*, *cinerea*, and *bigeloviæ*, they seem to prefer warm and rather dry situations, the adults hibernating and spreading over the beet fields in the spring in time to lay their eggs and produce their single brood of young there.

Agallia sanguinolenta Prov. is the most abundant species of the genus in the western country and is found in all fields. Together with *A. uhleri* this species has been observed to do considerable damage in the Arkansas Valley, in Colorado, and around Lehi, in Utah. The nymphs appear early in June and mature in the last half of July and the first half of August, a few running on through the month.

Agallia cinerea Osborn and Ball is found almost exclusively on the "shad scale" of desert regions, and from this adults often fly to near-by fields of beets. It was common at Grand Junction and Loma, Colo., and at Monroe, Utah. Under the hot desert conditions the nymphs appear in June and mature the last half of July, while on the beets they do not mature until some time later.

Agallia bigeloviæ Baker occurs in abundance on a tall species of sea-blite (Dondia) growing on alkaline soil, and has been found in the beet fields at Grand Junction and Palisades, Colo.

Agallia quadripunctata Prov. and *A. novella* Say belong to the other group of the genus and pass the winter as partially grown nymphs, which change to adults in late May and June. The nymphs appear again in August and develop slowly until fall, when they hibernate. These two species and *A. sanguinolenta* are discussed by Osborn and Ball (Iowa Experiment Station Report for 1897, p. 112), the nymphs and adults being figured and the life histories given. The dates given there are, however, too early for western conditions. This group thrives best in damp situations where rank vegetation abounds, and will not do any serious damage to beets unless planted alongside places of this character, from which the nymphs can migrate in early spring. By the time the adults are mature and ready to fly, the beets are well started and beyond their injury.

Empoasca sp.—A large number of adults of a small green *Empoasca* were found on sugar beets at Spreckels, Cal., in early September by Prof. E. G. Titus and the writer. The beet crop was not seriously injured, but a number of beets were found in which there was a slight curling of the leaves resembling "curly-leaf," except that in this case the edges of the leaf turned down rather than up, and the surface of the leaf, instead of being roughened, was covered with small pale spots. This pale spotting of the leaves is quite characteristic of the injury of the Empoascas and their relatives and is commonly seen on apple and rose leaves. The insects were all adults at this time, so that it was impossible to be certain that they had bred on the beets, but from the appearance of the leaves it is probable that they had. The nymphs of nearly all of this group are slender, pale-greenish forms and are found mostly on the underside of the leaf, while the white spots caused by their punctures show more plainly on the upper surface.

Professor Titus reports finding an Empoasca common on beets at Chino, Cal., in August, 1907, and states that the beet leaves showed the characteristic spotted appearance, but that no curling was noticed. In his trip in 1904 Empoascas were noticed in several places in California, and quite serious damage from "blight" or "curly-leaf" was found in a few places, but the particular nature of the injury was not observed.

The Empoascas nearly all pass the winter as adults, hibernating in rubbish and sheltered places near their food plants. In the spring they feed on anything that offers until their food plants start, and then they gather on them, laying eggs in early summer. The young nymphs feed on the underside of the leaf and are quite active and keep out of sight.

Spraying with kerosene emulsion, 1 part of the stock solution to 8 parts of water, proved to be a satisfactory remedy for an Empoasca on potatoes in Iowa some years ago, and no doubt could be used on the beets with success. Burning off rubbish around the field in the late fall would probably reduce their numbers.

CONCLUSIONS IN REGARD TO "CURLY-LEAF."

As a result of the above investigations, it appears that there are at least two distinct kinds of "curly-leaf" that have been confused under one name. One, in which the leaves become rough and warty and curl up and in which the beet is stunted and does not recover; the other, in which the leaves remain smooth but show numerous pale spots and in which the edges turn down, and in which, as far as known, the injury is confined to the leaves attacked. The first-mentioned kind of "curly-leaf" occurs from Grand Junction, Colo., west to the Pacific coast and is the one that has been seriously injurious in the intermountain region. This condition is brought about by the attack of the beet leafhopper (*Eutettix tenella*), and will, no doubt, be confined, for some time at least, to the southwestern part of the United States, the native home of this insect. The second kind of "curly-leaf" has been found in California quite commonly, and doubtless will be found to occur sparingly at least in the eastern part of the United States, or wherever an Empoasca attacks the sugar beet.

Besides these two types of this injury it is quite possible that in rare cases other types with still other causes have been seen and not recognized at the time as distinct. Investigations in the California field have been so meager that it is impossible to say as yet which type has caused the greatest injury. In the intermountain region, where most of the work has been done, practically all the injury is known to have been caused by the first type.

U. S. D. A., B. E. Bul. 66, Part V. Issued January 28, 1909.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE SEMITROPICAL ARMY WORM.

(*Prodenia eridania* Cram.)

By F. H. Chittenden and H. M. Russell.

INTRODUCTION.

During the summer of 1907 a smooth or hairless caterpillar (*Prodenia eridania* Cram.) related to the cotton cutworm came under the observation of the junior author at Orlando, Fla. It was observed attacking the foliage and, in many cases, the stems and fruits of all forms of garden truck grown in that vicinity, the list including tomato, potato, sweet-potato, eggplant, pepper, okra, collards, and cowpeas. The infestation was of considerable severity, and great injury was done in fields and gardens in that and in some other regions of Florida, notably at St. Augustine and on the west coast of the Manatee River. What is believed to be the same species was reported injurious in Porto Rico by Mr. W. V. Tower. Aside from a brief notice which has been made of the present invasion there does not appear to be any other record of the injurious habits of this species; hence the following account has been prepared for publication by the senior author. The chapters on recent injuries, natural enemies, and experiments with remedies have been compiled from the junior author's notes. The technical descriptions of the egg and larva have been prepared by Dr. H. G. Dyar, while other assistance in the preparation of this article is duly acknowledged in its proper place.

In ordinary seasons the species under consideration confines itself largely to weeds, among which are the poke-weed, spiny amaranth or careless weed of the South, and a wild Solanum. It has habits different from those of the northern cutworms and can scarcely be classified with the climbing cutworms, although it has the climbing habit. It has a decided tendency to travel in armies like the army worms and is practically confined to semitropical regions. It is remarkable as being injurious throughout the warm season and breeding continuously, there being evidently at least four generations a year in nature.

DESCRIPTIVE.

The adult is a noctuid moth, and while the larva is quite readily referable to the genus Prodenia, the moth has little of the appearance of our other two North American species.[a]

The moth.—The adult or moth has a wing expanse of nearly 1½ inches (33–38mm); the fore-wings are dull gray, sprinkled and dotted with brownish and black scales forming a pattern as shown in figure 8, *d*. There is considerable variability in these markings, some individuals having a strongly marked reniform spot, a very prominent blackish posterior marginal line, and a similar black line

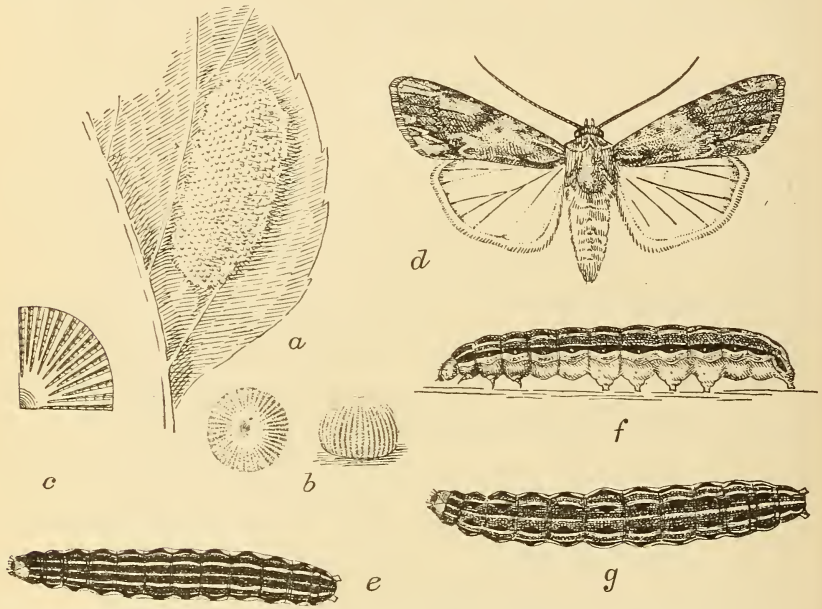


FIG. 8.—The semitropical army worm (*Prodenia eridania*): *a*, Egg-mass on leaf; *b*, egg, much enlarged, showing lateral view at right and top at left; *c*, section of egg; *d*, moth; *e*, dark form of larva nearly grown; *f*, *g*, larva, full-grown. *a*, *d–g*, Enlarged; *b*, highly magnified; *c*, more magnified. (Original.)

on the latero-posterior margin. Individuals also occur in which there is a straight, broad, jet-black dash or band beginning at the middle of the fore-wing and extending to the lateral margin. This is the *nigrofascia* of Hulst. The hind-wings are pearly white above, this pearly luster being still stronger below. The body is brownish gray and the antennæ are yellowish brown.

The darkest forms of this species are marked very much as in the genus Acronycta.

The eggs.—The eggs are deposited in irregular masses, as shown in figure 8, *a*, closely placed together, sometimes in two layers and

[a] *Prodenia ornithogalli* Guen. ("cotton cutworm") and P. *commelinæ* S. & A.

covered with whitish down, from the body of the female. They are distinctly green when first deposited and have the appearance illustrated at *b* and *c*.

The larva.—The caterpillar resembles that of the other two species of Prodenia sufficiently to be naturally referred to that genus, and it is subject to similar variation in color. The ground color is dark grayish in pale individuals and nearly black in the dark forms. These latter, especially when approaching maturity in the penultimate stage, are sometimes so dark as to resemble Mamestra. The body is ornamented with a narrow, slightly interrupted, median yellow longitudinal dorsal stripe, a similar slightly wider dorso-median stripe, and a wide and brighter yellow substigmatal stripe, which becomes obscured in the thoracic segments of the penultimate stage. In the very dark forms the triangular velvety dorsal spots characteristic of the genus can scarcely be seen, and in the paler forms they are seldom as distinct as in the other two species. When full-grown the larva measures about an inch and a fourth to an inch and a half in length (25–37^{mm}), and the width varies from one-fourth of an inch to a little larger. The head measures nearly 2.5^{mm}.

The mature larva is illustrated at *f* and *g* of figure 8 and a dark form nearly grown at *e*.

The pupa.—The pupa resembles closely that of *Prodenia commelinæ*. The head and abdomen are well rounded. The color is mahogany-brown, with the head, spiracles, and anterior edges of the abdominal segments darker. The surface is smooth and shining, with the anterior edges of the abdominal segments finely punctured. The anal segment terminates in a two-spined cremaster-like process. Length, 16–18 ^{mm}; width, 5–6 ^{mm}; length of head to end of the wing-cases, 10^{mm}.

The following technical description of the egg and larval stages was kindly contributed by Dr. H. G. Dyar.

TECHNICAL DESCRIPTION OF THE EGG AND LARVAL STAGES.

The egg.—Hemispherical, smooth, pale green, shining; ribs very fine, obscure, numerous, ill-defined, radiating from the micropyle; cross-striæ imperceptible. Diameter, 0.6^{mm}. Laid in a patch, covered by a thin layer of whitish wool.

Stage I.—Head rounded, bilobed, mouth pointed, shining greenish-black; eyes black, mouth brown; width about 0.3^{mm}. Body robust, uniform, joint 12 slightly enlarged, feet of joints 7 and 8 a little smaller than the others and not used in walking; translucent greenish, cervical shield, leg plates, thoracic feet, anal plate, and the large round tubercles shining black; tubercles i and ii of joint 12 in a square; setæ rather coarse, moderate, black, simple.

Stage II.—Head rounded, slightly bilobed, the vertex level with joint 2, shining luteous, blackish shaded over the vertices of the lobes; ocelli black, mouth brown, width, 0.4^{mm}. Body somewhat thickened at joints 5 and 12, feet normal, equal; greenish luteous, cervical shield and anal plate blackish infuscated;

tubercles rather large, low-conical, black; leg shields slightly smoky; tubercle vi present; a large red blotch around tubercles i and iv on joints 5 and 12; setæ short, black, stiff; traces of a white dorsal line showing especially by the cut between the red blotches at tubercle i of joint 5; no other lines.

Stage III.—Head rounded, the vertex just within joint 3, pale reddish over the lobes and sides, luteous on the face, shining, very small in proportion to the body; width, 0.6 mm. Body robust, slightly thickened at joint 5, more so at joint 12; feet normal; pale green; a straight dorsal and a subdorsal white line and traces of a broken lateral one; subventral region slightly pale, without defined line; tubercles small, black; a large, vinous, somewhat elevated blotch on tubercles i and iv on joint 5 and on tubercle i on joint 12, more diffusely about the spiracle on joints 11–12; anal feet reddish; cervical shield small, infuscated, cut by three white lines; anal plate blackish; thoracic feet blackish, abdominal ones greenish.

Stage IV.—Head rounded, rather quadrate, not notched, the clypeus high, vertex even with joint 2; pale red, paler on the clypeus, ocelli and antennæ dark; width 1.0 mm. Body robust, thickened at joints 5 and 12, feet equal; blackish olivaceous, dorsal and subdorsal lines straight, yellowish white, edged with vinous dottings; traces of a lateral line; subventral region paler below the spiracles, especially after joint 5; large blackish-red blotches at tubercles i and iv on joint 5 and on joint 12 and tubercle i and stigmatally on joints 11–12; white dotting in the ground color most conspicuous stigmatally; thoracic feet black, abdominal ones pale, anal pair reddish.

Stage V.—Head quadrate, rounded, slightly bilobed, shining light red-brown, the clypeus high; ocelli and setæ black; width, 1.6 mm. Body thickened at joints 5 and 12, feet equal, normal, the abdominal ones pale, slightly infuscated, the thoracic ones black-ringed; dark gray to black, strigose-dotted with white; dorsal line narrow, subdorsal broader, straight, even, yellowish white, centered with reddish mottlings, cutting the sooty-black cervical shield, but not the anal plate; a quadrate black patch between the lines on joint 5, a small angular one next the subdorsal line on all the other segments, large on joint 12 and shaded across; a narrow white-dotted lateral line, scarcely different from the dots of the ground color; subventral band straight, yellow-white, broad, broken at joint 5, reddish-filled around the spiracles, black spots at tubercles iii with a distinct white dot below; subventral region of thorax blackish, of abdomen paler, white-dotted.

Stage VI.—Head rounded, quadrate, about as high as wide, slightly bilobed, the vertex level with joint 2; clypeus high and large; red-brown, darker reticulate, mouth parts concolorous, ocelli black; width 2.1 to 2.4 mm. Body robust, cylindrical, tapering from joint 5 to joint 2, the head small; joint 5 slightly, joint 12 distinctly, enlarged and abruptly tapered to joint 13; black, strigose-dotted with white; cervical shield deep black, white-dotted, cut by three white lines; anal plate similar, small, cut by the dorsal line only; dorsal line narrow, black-dotted and broken, yellowish white, reddish on the centers of the segments; subdorsal line broader, straight, yellow-white, reddish centered on the segments, with a median row of gray dots, but not incised on the margins; a row of segmental black triangles above it, free of white dots, largest on joint 5, the one on joint 12 now scarcely larger than that on joint 11; upper half of the lateral area grayer, with many white dots, lower half blacker, with few dots on joints 5 to 13, separated by a row of brighter dots representing the lateral line; on joints 2 to 5 this distinction is weakly developed; spiracles in a blacker shade with a white dot above tubercle iv; substigmatal band broad, even, undulate, weak and broadly gray, centered on joints 2 to 5, fading out at

joint 5, sharply reappearing at joint 5 posteriorly, then pale yellow, centered with blackish mottlings at the centers of the segments and red above these; subventral region black-shaded, strongly so on joints 2 to 5, weakly on the abdomen, white-dotted, paling to the venter; thoracic feet dark brown, the abdominal ones pale brown, shining; a single cylindrical, round-tipped neck gland reaching to the end of the labial palpi; crochets of abdominal feet in a single row, dark; tubercle iv slightly above middle of spiracle on joint 7. [Harrison G. Dyar.]

ORIGIN AND DISTRIBUTION.

This is a Lower Austral form and probably of tropical origin. In the National Museum are specimens from Cocoanut Grove, Crescent City, and Orlando, Fla. The species is also recorded from Tallahassee, and reported from St. Augustine and the region about the Manatee River in Florida. From Texas we have specimens from Bosque County (Belfrage) and Dallas, and there are specimens collected at Pernambuco, Benito Province, Brazil, by Mr. Albert Koebele. Dr. J. B. Smith records the insect from Georgia and Central and South America, and Grote records it from California. This indicates a range extending from Brazil to Mexico, Central America, and the Antilles, and from Florida westward through the Gulf region and Texas to California.

LITERATURE AND HISTORY.

Considering the fact that this species is really common in the South and that it feeds gregariously and voraciously, it is somewhat remarkable that it has not hitherto attracted attention by its depredations. The moth was described by Pierre Cramer in 1782.[1a] Its natural food plants were known to Smith and Abbot, who wrote of it in their classic work published in 1797.[2] The illustration accompanying that work, though over-colored as usual, depicts a perfectly recognizable moth of this species but a too-brilliant and light-colored larva. Light and dark forms of the moth are figured. The species is mentioned as *Phalæna phytolaccæ* and is compared with the related *Prodenia commelinæ* and *Laphygma frugiperda*, which form the subject of the two plates and pages immediately preceding the account of *phytolaccæ*.

As Smith and Abbot's work is not accessible to many, the following copy of their account of this insect is republished:

PHALÆNA PHYTOLACCÆ. Poke-weed moth.

Phytolacca decandra. Linn. Virginian poke-weed.

Ph. *Noctua* spirilinguis cristata, alis deflexis: primoribus fusco striatis puncto obscuro margine postico nigro maculato; anteriori punctato.

[a] Numbers in superior type refer to corresponding numerals in the appended bibliographical list (p. 70).

Feeds on the Poke, Careless, &c. It went into the ground July the 5th, and came out the 16th. I once met this caterpillar in such abundance, that among a great quantity of Poke plants there was scarcely a single leaf untouched; most of these caterpillars, however, were fly-blown by a kind of *Ichneumon*. The moth is rare.

This is allied to our *Ph. frugiperda* and *Commelinæ*. Between the under wings of all these there is the greatest affinity. Their *pupæ* too are of a similar bright red color, and their smooth-striped caterpillars have much resemblance to each other.

RECENT INJURIES AND BIOLOGIC NOTES.

On May 14, 1907, this species was observed on the leaves of tomato in the truck garden of Mr. C. M. Berry, at Orlando, Fla., where it was eating holes in the leaves. Numbers of plants, here and there, were infested and in most cases the entire plant was injured. The same larva was observed on pokeweed (*Phytolacca decandra*), and afterwards on spiny amaranth (*Amaranthus spinosus*). By May 20 the larvæ were scattering and had grown rapidly, some being an inch long. While young, these larvæ feed on the underside of the leaf, but with larger growth some were noticed feeding on the upper surface as well.

May 24 an egg-mass was found on a leaf of the spiny amaranth, laid in two sections on the under surface, one on each side of the midrib. One mass had hatched at this time and the larvæ were beginning to eat pinlike holes through the leaf.

On July 3 a field of Irish potatoes was found to be very badly infested by these larvæ. They were now nearly full-grown and had stripped the potato vines, many being observed crawling away from the field in all directions. On one side they infested a garden at least 600 feet away, and were feeding upon eggplant, pepper, okra, and castor-oil plants.

Some interesting notes were made on the abundance of this species in this potato field. On a single young plant of Amaranthus, 41 larvæ were counted, and as many as 314 on a plant measuring 6 feet in height. A careful estimate of the larvæ on 10 plants of careless weed, not over 6 feet in height, gave a total of 1,300 individuals. (See fig. 9.)

To illustrate the voracity of these larvæ, where any potatoes were exposed, they were soon covered by the larvæ and the entire contents eaten out so that they were rendered worthless in about ten minutes. About this same date, July 3, the larvæ were reported making quick work of amaranth; whenever a branch became broken from any cause, larvæ entered at the break and excavated tunnels several inches in length. Pokeweed was entirely stripped of leaves, the stalks and the shoots being eaten off at the outer end. Potatoes dug

at this time were frequently found full of holes, the work of these larvæ. The following day, July 4, the amaranth was almost completely denuded, illustrating the rapid work of this species when in large numbers (see figs. 10, 11). By July 8 the larvæ had almost completed their work in the field, after having eaten everything clean. Many were full grown and had commenced to enter the ground. July 9 the potato field was stripped, the vines were dead and dry, and the larvæ had almost disappeared. The ground was full of pupæ, none of them at a greater depth than 4 inches, and in

FIG. 9.—The semitropical army worm (*Prodenia eridania*); Work of larvæ on "careless weed" in potato field; 311 larvæ were on this plant when photographed. (Original.)

many cases only 2 inches. Upon digging into the hills, it was found that they did not average more than four good-sized potatoes to the hill, and in many cases these had been rendered useless by the inroads of the larvæ. (This crop averaged small because of late planting.)

Many larvæ were found feeding on sweet potatoes at Mr. John M. Cheney's place at this time, most of them still in young stages. A few fully matured larvæ also were found, showing the overlapping of the two generations; in fact, observations conducted both in the

field and at the insectary at Washington, D. C., show that this species is undoubtedly a continuous breeder, as in the case of the variegated cutworm (*Peridroma margaritosa* Haw.), the larvæ being present in the field throughout the long summer season of the South.

July 30, by request of the county commissioner, Mr. H. H. Dickson, the junior author went to the County Home and found a sweet-potato patch badly infested, thousands of larvæ present, and the leaves turning brown and drying out. Superintendent Harris stated that an earlier brood did great damage to cowpeas, but this could not be verified by specimens. In the sweet-potato field the larvæ started on the south side and, after stripping the first four or five rows, moved over to the next rows and eventually infested the entire

FIG. 10.—The semitropical army worm (*Prodenia eridania*) : Field of late Irish potatoes showing vines entirely stripped by larvæ ; Orlando, Fla., July 6, 1907. (Original.)

field. A Mr. Porter, near the County Home, reported 5 acres stripped in three days after the larvæ were noticed at work, these having started at one side of the field and swept it clean. The larvæ of a third generation were observed at Mr. Cheney's place at this time; most of them, however, had already gone into the earth to transform.

August 3, adults that had pupated about July 25 began to emerge. Thus the pupal period occupied about nine days. At this time a number of young larvæ were noted feeding upon amaranth, wild Solanum, and castor-oil plants. When disturbed they dropped and hung by threads.

By the first of September Mr. Cheney's patch of sweet potatoes was entirely free from this insect, evidently owing largely to parasites and to the spraying with arsenate of lead.

August 30, 1907, Mr. Wm. Donnell, St. Augustine, Fla., reported that a cutworm, which he identified as this species, had been very destructive in that region, being especially abundant on beets, and

FIG. 11.—The semitropical army worm (*Prodenia eridania*) : Larvæ eating bark of "careless weed;" also nymph of *Podisus maculiventris*, predaceous on the larvæ. (Original.)

later affecting cabbage, carrots (by eating the tops), and some other plants, its operations being most noticeable at night.

Mr. E. L. Worsham, while employed by this Bureau, noticed this species on the west coast, near the Manatee River, in Florida, and reported it working quite extensively in that region in August.

On November 23, 1907, an egg-mass was found on pokeweed at Dade City, Fla., and December 2 another was observed, from which

the larvæ hatched December 4. These molted between December 10 and 13, while being transported to Orlando, but soon died, as frost killed off the food plants.

July 25, 1908, Mr. H. H. Dickson asked for a remedy to apply against the larvæ on sweet potatoes at the Orlando Truck Farm.

Egg-masses received May 24, 1907, hatched at that time and the larvæ entered the earth in the rearing cage June 19. In dry sand the pupæ were found at a considerable depth, but in moist sand they were found barely under the surface.

July 8 larvæ in the rearing-cage were almost full grown. Larvæ hatching from egg-masses, and others a few days old, were also found in abundance on sweet-potato plants. As soon as hatched they separate, feeding on the leaf on which the egg-mass was laid, perforating the underside full of minute holes, and leaving only the upper epidermis, which turns brown. On growing larger they separate, as in the case of most caterpillars, except those of peculiarly gregarious habit, and soon become widely scattered. Even when abundant it is common to see eight or a dozen on the underside of a single leaf, and frequently as many as an hundred. Occasionally a nearly full-grown larva feeds on the upper side of a leaf. In many cases large larvæ were found hiding during the day at the bottom of furrows.

June 15, 1908, the larvæ of this insect were found to be very abundant at Orlando, Fla., in one part of the town feeding on pokeweed, and in another on amaranth.

EARLY RECORDS.

Among the records of the Bureau of Entomology is one of May 22, 1887, when larvæ and pupæ were received from Mr. E. A. Schwarz with report that the species was very injurious to the eggplant at Cocoanut Grove, Fla.

In September, 1905, Mr. F. C. Pratt sent to the Bureau a large colony of the larvæ found feeding on pokeweed at Dallas, Tex., the moths from which began to issue September 26.

LIFE-CYCLE PERIODS AND GENERATIONS.

Larvæ mailed from Orlando, Fla., July 3, arrived at Washington, D. C., July 5 and began to enter the earth for pupation the following day. On the 16th two had transformed to pupæ, on the day following three more, and the remainder transformed within a week. This experiment shows a pupal period of about 9 days, allowing 1 day for the larvæ in the earth before pupating. The weather was quite hot. In a cooler temperature in August the pupal period required 11 to 13 days.

The moths hatched from different lots were separated and the egg-period observed. In one case this lasted from August 8 to 12, or

4 days, and in another case from July 18 to 22, or 4 days. In the first instance the temperature averaged between 76° and 80° F. and in the second from 80° to 88° F. Evidently this is the maximum period.

As regards the duration of the entire life cycle, it was noticed that eggs deposited July 3 produced caterpillars on the 9th, or in 6 days. These penetrated the earth, being full-grown, on the 26th, making the entire life period of the larvæ 17 days. They began to issue as moths August 5. This gives a total period for the life cycle of 31 days for extremely hot weather. In an ordinary outdoor summer temperature the period would be about 35 days, or 5 weeks.

Our rearing records are not quite as accurate as could be desired, owing to unfortunate conditions at the insectary and to three changes in the office force during the time when the insect was under observation. There were, however, positively four generations here, and about the same number was observed at Orlando. There is also the possibility of an earlier fifth generation in nature. The exact periods for the appearance of these should be recorded in the field.

NATURAL ENEMIES.

The unusual abundance of this species at Orlando, Fla., during the season of 1907 afforded a most excellent opportunity for the study of its insect natural enemies. These came under observation as early as May and were still abroad as late as August, appearing to increase somewhat as the season advanced.

PARASITES.

The parasitic species observed were seven in number; the predaceous enemies, six.

Ophion tityri Pack. (?)—Issued July 17–August 1.

Limnerium sp.—Issued May 25–30.

Meteorus sp.—Issued July 11–August 2.

Chelonus sp.—Issued July 6, 1908.

Spilochalcis spp.—The Meteorus was attacked by two species of secondary parasites of the family Chalcididæ. These issued August 2 from the peculiar brown cocoons of the Meteorus.

Winthemia quadripustulata Fab., a moderate-sized tachina fly, is also a parasite on the larva of this species. Adults issued August 8 but did not appear abundant. Of a lot of larvæ taken at random from different portions of a field, upward of 50 per cent bore tachina-fly eggs. Evidently a large percentage fail to hatch.[a]

[a] A small fly was also observed feeding on the pupæ. It is *Aphiochæta nigriceps* Loew, one of the Phoridæ, which comprises species of scavenging habits and not parasitic.

PREDACEOUS ENEMIES.

Calosoma sayi Dej.—The larvæ of the carabid beetle *Calosoma sayi* were observed in considerable numbers and were reared to adults. They were first noticed July 6, when they were quite abundant in the furrows between rows of sweet potato. They were found concealed by the vines, feeding on the larvæ of the Prodenia, and after sucking out the juices of one larva they immediately attacked another. The adults issued in our rearing cages August 11.

Polistes annularis L.—The large brown wasp *Polistes annularis* was observed July 2, flying quite commonly in sweet-potato fields. One was watched which alighted on a leaf and began searching for prey, after the custom of such wasps. The search was continued from plant to plant and from leaf to leaf until a Prodenia larva was located, when it was at once seized behind the head and chewed into a shapeless mass. Other wasps of this species were also seen on fence posts dragging Prodenia larvæ about with them.

It is interesting to note that Mr. F. F. Crevecoeur, Onaga, Kans., reports having seen this wasp being carried away by the asilid robber-fly, *Deromyia ternata* Loew.

Stiretrus anchorago Fab., var. *diana* Fab.—The blue-and-red and the uniformly blue forms of the soldier-bug *Stiretrus anchorago*, which are common in Florida, were observed in numbers attacking the Prodenia larvæ in July.

Podisus maculiventris Say.—During July the spined soldier-bug was seen preying upon the Prodenia larvæ. (See fig. 11.) In one instance 18 nymphs were counted on a single amaranth plant infested by the cutworm. The length of the life cycle of this species from hatching (not from egg-laying) was determined to be 16 days in hot July weather.

Apateticus (*Eupodisus*) *mucronatus* Uhl.—July 17, and again in December, 1907, this pentatomid bug was observed preying on the larva of this species of Prodenia at Orlando, Fla. It is considered a rare species and this is probably the first observation which has been made on its habits.

Owing to the obscurity of the host insect in the past, no records can be found of any of these parasites or of other natural enemies which affect it, but in Smith and Abbot's work mention is made of a species of " Ichneumon " which attacks the larva (see p. 58).

Pontia rapæ L.—July 22, 1907, the young larvæ of the imported cabbage worm, which had hatched out on cabbage used as food for *Prodenia eridania* Cram. in our rearing cages at Washington, were

observed feeding on the eggs of the latter.[a] The cabbage worms were between one-quarter and three-eighths of an inch in length at this time.

A FUNGOUS DISEASE.

Empusa sp.—September 8, 1907, a few Prodenia caterpillars, which were found dying of a fungous disease in our rearing cages, were referred to the Bureau of Plant Industry for identification of the fungus. Mrs. F. W. Patterson stated that it was a species of Empusa.

METHODS OF CONTROL.

The arsenical poisons are effective against this army worm under ordinary conditions. Experiments performed at Orlando, Fla., however, brought out the fact that Paris green, on account of the frequent rains which occur at the height of the principal outbreaks in the infested regions of Florida, such as Orlando, is almost ineffective and it is therefore necessary to use arsenate of lead. Owing to the greater adhesiveness of the latter it remains on the plants when the former is washed off.

Paris green, arsenate of lead, and a special preparation which may be called adhesive copper arsenite, were tested, the last by request of its inventor. It was used in experiments Nos. 8, 10, and 11. A barrel sprayer, fitted with Vermorel nozzle, was used for a number of these experiments, but for most of them a knapsack sprayer of fine quality was employed. Sweet potatoes were sprayed in every case except in experiment No. 5, where collards were also sprayed, and the work was usually begun between 8 and 10 a. m. in bright sunlight. Spraying experiments commenced July 12 and were continued until August 7.

Experiment No. 1.—July 12, infested plants were sprayed with a solution of Paris green, 5 ounces, and freshly slaked lime, 5 ounces, in 50 gallons of water. The spraying was done in the morning and rain fell before noon. The next day when the field was examined the larvæ were found uninjured and practically no poison remained on the leaves. The experiment was therefore a failure.

Experiment No. 2.—July 12, Paris green, 8 ounces, and freshly slaked lime, 1 pound to 50 gallons of water, were sprayed the same day and with the same results.

Experiment No. 3.—July 17, Paris green was sprayed as in No. 2. Again rain fell hard and steadily before noon, with the same results as in experiments 1 and 2.

---

[a] This would seem to furnish at least one reason why this important insect has been able to supplant its American cousins such as *Pontia napi* L., *P. protodice* Bdv. & Lec., and *P. monuste* L., all of which feed on crucifers and are called cabbage butterflies or "worms."

Experiment No. 4.—Arsenate of lead, 2 pounds to 50 gallons of water, was used. Rain fell as before, resulting in partial failure of the experiment, the poison being washed off before it had time to dry thoroughly.

Experiment No. 5.—July 20, arsenate of lead was used as in experiment No. 4. Collards were also sprayed. Rain did not ensue for at least six hours, giving the spray time to dry on well in the warm sun. The following day it rained hard for several hours, but the next day the spray was found to be as thick on the sweet potatoes as when first put on, in spite of two partially rainy days. The poison was nearly as thick on the collards. An examination of the infested plants two days after spraying showed that only 25 per cent of the caterpillars were killed, but July 23, a day later, few large larvæ remained on the plants, showing that as soon as they have eaten sufficient poison they are killed.

July 29, when the rows sprayed with arsenate of lead were again examined, they were found in much better condition than the check or unsprayed rows, few larvæ being seen feeding, while dead ones were plentiful.

Experiments Nos. 6 and 7.—July 20, a sweet-potato patch was sprayed with Paris green, 8 ounces to 50 gallons of water. As in the case of experiment 5, no rain fell for about six hours; therefore the poison dried on well, as previously. The following day it rained hard for several hours, with the result that by July 22 the poison was all washed off and only a few dead larvæ were found. All of the Paris green experiments were failures, since the rain washed the poison off either before it could dry or after it was well dried on the plant.

Experiment No. 8.—July 23, the adhesive copper arsenite (combined with dextrine and glucose) was used at the rate of 1 pound to 100 gallons of water and applied as in previous experiments. The following day no results were observed, but the foliage was not burned. At the end of a week no good was accomplished and the experiment was pronounced a failure.

Experiment No. 9.—July 25, plants were again sprayed with arsenate of lead, 2 pounds to 50 gallons of water, the conditions being as in experiment No. 5. Rain at 12.45 p. m. washed off the poison, consequently the spraying was a failure.

Experiment No. 10.—July 25, plants were sprayed with the copper arsenite mixture; 10 ounces to 50 gallons of water were applied as in experiment No. 8, an equal quantity of lime having been added. The spray did not show well on the foliage and was invisible when dry. It does not remain in suspension as well as Paris green and much residue remains in the tank. July 28, a few dead larvæ were found

on the vines and only a few live ones, but the same conditions were observed on the check rows. The experiment was an absolute failure.

Experiment No. 11.—July 29, plants were sprayed with copper arsenite mixture at the rate of 15 ounces to 50 gallons of water. In this case 1½ ounces of copper arsenite and 1 quart of thick lime were used with 5 gallons of water. Two days later the spray showed better than in experiment No. 10 because of an abundance of lime and was very finely and evenly applied to the leaves. Four larvæ were dead on a few plants examined against 32 living Prodenia and 3 living sweet-potato sphinx-moth larvæ (*Phlegethontius convolvuli* L.).

August 6, this spray still remained on the foliage, seeming to adhere well, but the experiment was a failure in killing larvæ.

Experiment No. 12.—July 29, plants were sprayed with arsenate of lead, 3 pounds to 50 gallons of water, applied as in previous experiments with lead arsenate. There was no rain for 24 hours. On a few plants examined three days later 41 dead larvæ were found and 49 living, an observed death rate of less than 50 per cent. It should be pointed out at this time, however, that it is difficult to find dead larvæ, as they sometimes dry up or crawl away.

August 2, the vines were almost free from larvæ. The experiment was pronounced very successful.

Experiment No. 13.—July 30, arsenate of lead, 2 pounds to 50 gallons of water, was used without ensuing rain. In some rows examined August 1 about 20 per cent of the larvæ were dead; in others 48 per cent, 54 per cent, and 61 per cent were killed in two days. August 5, these rows appeared entirely free from larvæ unless closely inspected, when only 5 or 6 could be found to a row. These might have crawled from unsprayed weeds or other plants.

Experiment No. 14.—July 30, arsenate of lead, 3 pounds to 50 gallons of water, was used. Three days later 84 per cent of the larvæ under observation were destroyed, the rows being quite clean. In both of these experiments, 13 and 14, many dead larvæ were found in rows *not* sprayed, as many as five rows away from the sprayed ones.

Experiment No. 15.—August 7, arsenate of lead, 2 pounds to 50 gallons of water, was sprayed by a laborer, under supervision. It rained at 1 p. m., but the spray remained on the leaves in large amounts and, for having been applied by an inexperienced hand, was well distributed. In this experiment, for some reason, the first four rows sprayed at one filling of the tank produced quite a number of burned leaves. This was attributed to a possible mistake in weighing out the chemicals. It did not, however, permanently injure the plants.

Caterpillars in the last 4 experiments, supposedly of the third generation, were very small, not over one-fourth or one-third of an inch in length. As a consequence they were quickly killed, large numbers

of them being found dead soon after spraying. Forty-three dead larvæ were found in a furrow beside one plant which contained 29 dead larvæ. In another place 112 dead larvæ were counted in 3 feet of furrow.

RÉSUMÉ OF EXPERIMENTS, AND CONCLUSIONS.

Experiments 1, 2, 3, 6, and 7, in which Paris green was used at the rate of 5 to 8 ounces in 50 gallons of water, were failures because in each case the rain which followed the application washed off the poison.

Experiments 4 and 9, in which arsenate of lead was used at the rate of 2 pounds to 50 gallons of water, were also failures for the same reason.

Experiments 8, 10, and 11, in which copper arsenite was used at a rate of from 10 ounces to 1 pound in 50 gallons of water, failed, not because of burning the foliage, as was feared, but because the insects were not killed.

Experiments 5, 12, 13, 14, and 15, in which arsenate of lead was the insecticide employed at the rate of 2 to 3 pounds in 50 gallons of water, were successful in each case.

The results of this series of fifteen experiments show conclusively the superiority of a spray of arsenate of lead to one of Paris green when applied under suitable conditions. It is in every way more effective and more satisfactory than the latter, as Paris green is so likely to be washed away by the frequent rains of the wet season of Florida. These remarks apply practically to all cutworms, caterpillars, and other larvæ which devour truck and related crops in central Florida or similar regions.

ADHESIVE COPPER ARSENITE MIXTURE.

The preparation of copper arsenite used in the experiments that have just been reported was stated by its inventor to be free from soluble arsenious acid and to possess the adhesive properties found in no other adhesive insecticide. It was stated to be composed of 36 per cent dextrin and 4 per cent gum and was prepared to be used in conjunction with lime in the proportion of 1 part by weight to from 4 to 6 parts of lime—either dry or in solution, according to the foliage to be tested. The inventor also expressed his confidence that this insecticide would prove a most economical one for general garden and other use, as the loss by wind and rain would be reduced at least 50 per cent and the first cost of the article would be about half that of Paris green or arsenate of lead.

Samples of this mixture were submitted to Mr. J. K. Haywood, Chief of the Miscellaneous Laboratory, Bureau of Chemistry, who furnished the following analysis, August 7, 1907:

Analysis of 4551 Misc.

	Per cent.
Moisture	4.85
Total arsenious oxid	40.42
Total copper oxid	24.87
Gum and dextrin (approximate)	20.00
Acetic acid and other undetermined	9.86
Total	100.00
Soluble arsenious oxid	11.36

(10 day water ext. method.)

From the above analysis the sample evidently consists of about 20 per cent gum and dextrin and 80 per cent Paris green. The amount of soluble arsenic is very high and would undoubtedly give rise to serious trouble.

SUMMARY.

The semitropical army worm is a smooth or hairless noctuid caterpillar, *Prodenia eridania* Cram. It feeds normally on weeds, such as the pokeweed and spiny amaranth or "careless weed" of the South, and is confined to semitropical America as a pest. When it becomes unduly abundant it attacks the foliage and, in some cases, the stems and fruits of all forms of garden truck growing in its habitat, the list of known food plants including tomato, potato, sweet potato, eggplant, pepper, okra, collards, and cowpeas. In its habits it is similar to the cutworms, having also the climbing habit, and when extremely abundant it migrates in armies like the common army worm, whence the name.

Experiments show that the egg period may be passed in a minimum of 4 days, the larval period in 17 days, and that the entire life cycle, in an outdoor summer temperature, would be about 35 days or 5 weeks; also, that there are four generations and possibly five produced in a year, the insect breeding practically continuously during the warm season. In ordinary years the species is largely controlled by natural enemies, of which seven are parasitic and six predaceous.

A series of fifteen experiments was conducted against this species in Florida during 1907, which shows conclusively that a spray of arsenate of lead is the best remedy, being much superior to Paris green when applied under local conditions. It is in every way more effective, chiefly because less likely to be washed away by the frequent rains of the wet season in that region. It is best applied at the rate of 2 or 3 pounds in 50 gallons of water, and applications must be renewed when the insects again become numerous, as the latter are apt to spread from unsprayed plants.

BIBLIOGRAPHICAL LIST.

1. Cramer, Pierre.—Papillons exotique, Vols. III & IV, p. 133, pl. 358, fig. E. & F. (2), 1782.

Description and figures of both varieties of moths.

2. Smith, J. E. and Abbot, M. J.—Lepidopterous insects of Georgia, Vol. II, p. 193, pl. 97, 1797.

Described as *Phalæna phytolaccæ* with brief account of habits. Figures of moth and larva.

3. Grote, A. R.—Bul. Buff. Soc. Nat. Sci., Vol. II, p. 28, 1873.

Listed as *Xylomiges phytolaccæ* (S. & A.) and recorded from California and Atlantic District.

4. Morrison, H. K.—Proc. Acad. Nat. Sci. Phila., p. 62, 1875.

Technical description as *Actinotia derupta* n. sp., from Texas, September 21. Briefly compared with *phytolaccæ* S. & A.

5. Grote, A. R.—Can. Ent., Vol. XI, pp. 205, 206, 1879.

Received from Texas and referred to *Prodenia phytolaccæ;* characters, etc. No excuse for Morrison's *Actinotia derupta.*

6. Hulst, G. D.—Bul. Brooklyn Ent. Soc., Vol. III, p. 77; Vol. IV, p. 7, pl. 1, fig. 9, 1881.

Described as *Leucania nigrofascia* from one specimen taken by Koebele at Tallahassee, Fla.

7. Smith, J. B.—Catalogue Noctuidæ Boreal America, p. 169, 1893.

Bibliography; synonymy and distribution.

8. [Chittenden, F. H.]—Yearbook U. S. Dept. Agr., 1907 (1908), p. 545.

Brief unsigned notice of injury to truck crops in Florida.

In Smith's catalogue of Noctuidæ,[7] fifteen references are given to this species, but as only a few of these are of interest in connection with the present account, the reader is referred to that list. The more important references are listed above.

U. S. D. A., B. E. Bul. 66, Part VI. Issued May 8, 1909.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

THE HOP FLEA-BEETLE.

(*Psylliodes punctulata* Melsh.)

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Special Insect Investigations.

INTRODUCTORY.

A minute, metallic blackish flea-beetle, *Psylliodes punctulata* Melsh., known by different local names, has been reported in recent years as doing very extensive injury to the hop plant and considerable injury to sugar beet. Since 1904 it has been reported in numbers on sugar beets grown in several localities in Idaho, Utah, and Colorado. In the Northwest, and particularly in British Columbia, it does serious damage in hopyards, and has been especially destructive since 1903. During the past three years, indeed, this species has become unusually abundant, with the result that in the Chilliwack and Agassiz Valley hop-growing regions of British Columbia it has accomplished damage which has been estimated by Mr. H. J. Quayle as about 80 per cent of the crop. Mr. Theo. Eder informs the writer that this means a cash loss of not less than $125,000 in that district. The species during that period has been the subject of considerable correspondence between this Department and persons practically interested in the growing of hops in the affected region.

The insect has received the name of rhubarb flea-beetle, from its common occurrence, especially in the East, on rhubarb. In the West it is called the hop flea-beetle, or "hop flea," or simply "flea," and in literature it has received mention as the punctulated and the small-punctured flea-beetle.

While the species is not known to be of the highest importance as a sugar-beet pest, the probabilities are that it may become so, and at the present time it is probably the most important hop pest in the entire world. The incorporation of some new matter, gained from conversation with Mr. Theo. Eder and by correspondence with Mr. H. J.

Quayle, has added much to the value of the present paper. Although the species is much more serious as a pest in British Columbia than in the United States, it is likely to become important throughout the Pacific coast region where hops are grown. Mr. Eder represents the E. Clemens Horst Company, which owns extensive hop-yards in British Columbia, and has already expended considerable sums in investigation and experiments. The hop flea-beetle is now abundant practically on the border line between British Columbia and the State of Washington, and threatens our own industries. It is, therefore, advisable that everything possible concerning it should be made public before its appearance in the spring, although there are several points in its life history still to be worked up.

DESCRIPTIVE.

The hop flea-beetle (fig. 12) is a member of the tribe Halticini, family Chrysomelidæ, and resembles other flea-beetles in its strongly

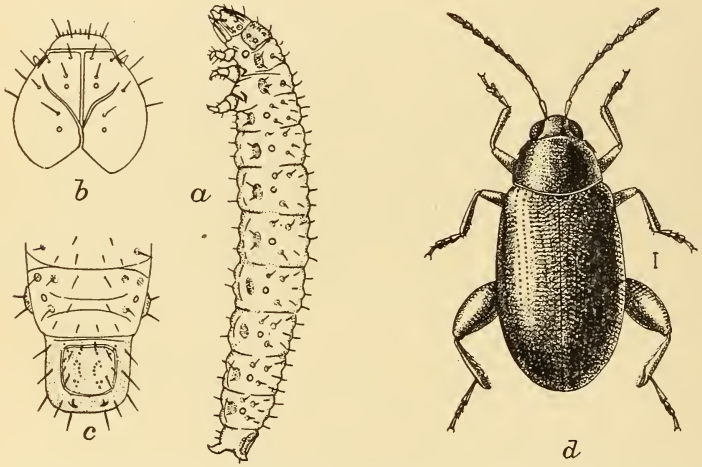


FIG. 12.—The hop flea-beetle (*Psylliodes punctulata*) : *a*, Larva ; *b*, lower surface of head of same ; *c*, upper surface of anal segments of same ; *d*, beetle. *a*, *d*, Much enlarged ; *b*, *c*, more enlarged. (*a–c*, After Carpenter ; *d*, original.)

developed hind thighs. It is of oval form, with a greenish tinge, brassy blackish, and punctulate or finely punctured, whence its specific name. The femora, tarsi, and basal joints of the antennæ are pale yellowish. The punctulations of the thorax are particularly fine and appear as if made with the point of a very fine needle. The punctures of the elytral striæ are closely placed, almost crenate. The beetle is only about one-tenth of an inch (2^{mm}) in length and less than 1^{mm} in width. The male is particularly distinctive, having the first joint of the anterior tarsi broadly dilated and the last

ventral segment sinuate each side, while the middle of the disk near the apex has a semioval depression.[a]

The species was first described in 1847.[1] [b]

DISTRIBUTION.

The hop flea-beetle is a native American species, quite distinct from any species found on hops in England or on the Continent.

The collection of the U. S. National Museum and the published records and specimens before the writer show the species to be generally distributed in the northern United States and southern Canada, from the Atlantic to the Pacific. It does not appear to occur south of Nebraska. The list of known localities follows: Cambridge, Mass.; Dundee, Ithaca, Long Island, Staten Island, and New York, N. Y.; New Jersey, generally distributed (Smith); Pittsburg, Pa.; Marshall Hall and Cabin John, Md.; Marquette, Detroit, Grand Ledge, and Byron, Mich.; University, N. Dak.; Lincoln and Omaha, Nebr.; Fairfield, Wyo.; Denver, Longmont, Grand Junction, Delta, Montrose, Paonia, and Ft. Collins, Colo.; Logan, Garland, Lehi, Salt Lake, and Park City, Utah; Elko, Nev.; Blackfoot, Idaho; San Francisco, Martinez, Monterey, Huntington Beach, Pasadena, and Chico, Cal.; Tenino, Wash.; Astoria and Marion, Oreg.; Agassiz, Sardis, and Vancouver, British Columbia; Northwest Territory; Manitoba; and "Assiniboia" (now Saskatchewan).

RECENT INJURIES.

September 16, 1903, the late Dr. James Fletcher first reported this species injuring hops in British Columbia.

During 1906 Mr. Theo. Eder wrote from San Francisco, Cal., under date of April 9, that hop growers were troubled considerably in some sections by "hop fleas," or flea-beetles. May 29, specimens were received from Perkins, near Sacramento, Cal., which proved to be the species under consideration. August 13, Mr. Hugh F. Fox, New York, N. Y., sent specimens and transmitted a report from Mr. Geo. Heggie, manager of a large hopyard, the Stepney ranch, owned by Sir Arthur Stepney, at Enderby, B. C., where this pest was very injurious. Mr. Heggie wrote as follows:

> We have been sorely troubled this year in our hopyard with the "hop flea-beetle," which attacks the young vine and leaf as soon as they appear above the ground, and eats out large holes in the leaf, resulting in the plant being

[a] In the very closely related *Ps. convexior* Lec. the last ventral segment of the male is convex and not impressed. The latter species is, moreover, larger, broader, and more convex, and the elytral striæ are not impressed.

[b] The numbers in superior type refer to corresponding numbers in the appended bibliography, p. 91.

impoverished in vitality and the growth thereby seriously retarded. We were troubled with them last year [1905], but not to the same extent, and had them till after hop picking. In the middle of July they were so numerous that the ground was fairly alive with them. They go into the ground in the evening and come out again in the morning, and there has been no spray found to have any effect without killing the plant.

Substantially the same form of injury was reported during the same year at Agassiz, B. C., by Mr. John Wilson in a letter to Doctor Fletcher. Writing September 7, 1906, Doctor Fletcher stated that this species had been enormously destructive in British Columbia, one correspondent reporting the loss of many thousands of dollars. He estimated his crop as possibly 70 bales, whereas he should have had 250.

Writing of this species, January 30, 1907, Dr. E. D. Ball, while working in cooperation with the writer, stated that it was by far the most injurious species on sugar beet in Utah. It was found everywhere and was apparently the most common species in early spring. It was observed hibernating around the edges of fields, in patches of dead mustard, along ditch banks, and in similar places. Where ditches were covered with patches of roses these seemed to furnish a favorite retreat. These clumps grew to a height of 2 or 3 feet and were very dense, and from them one could see the injury to the beets radiating in every direction, the affected area growing wider and wider as time went on. In early spring this species fed on almost anything that came to hand, but its injury to beets was practically all done at the time the plants were first appearing through the ground or within a few days thereafter. Cases were observed where the rows of young plants could be seen the entire length of the field one day, and two days later scarcely a beet plant could be found, the beetles having eaten the tender stem, causing the tops to fall off and the beets to die. Frequently they attacked beets just as the latter were pushing through the ground. Hundreds of acres had been destroyed in this way, injury varying greatly in different years and in different localities.

Great damage was done near Logan, Utah, where the hedge mustard was overrunning the fields. At Lewiston, Utah, at the northern end of the same valley, injury was also severe, although there was little of the common black mustard.

The destruction of a crop by this species does not necessarily entail a complete loss, as the growers replant. The late plants, however, are not, as a rule, as good as the earlier ones, and the weeds get such a start that the land is hard to cultivate. After the beets had reached a leaf diameter of 3 or 4 inches no material injury was noticed, although the beetles continued to appear in the fields throughout the season. Beetles were observed July 20, 1906, at Cache Junction,

Utah, enormously abundant on a form of hedge mustard along the railroad tracks, feeding on the half-grown seeds. Single plants were seen on which a double handful of beetles could be taken at one stroke of the net.

In a letter dated July 20, 1908, the E. Clemens Horst Company, Perkins, Cal., wrote of extensive injury by this species, and as this letter contains much of interest it is transcribed herewith. The writer is greatly indebted to the same company for the excellent photographs from which the ten half-tones illustrating this article are taken.

We are extensive growers of hops on the Pacific Slope, California and Oregon, and also have about 600 acres of hops in two ranches in British Columbia. For the past three years we have been very much molested in British Columbia by a variety of flea-beetle that seems to take an especial liking to hop foliage and eats the young, tender shoots as they come out of the ground, and also the developed and partly developed leaves of the vines after the same are above ground. There are two other growers in the same section that were bothered one or two years previous to ourselves, and as they had some foreign varieties of hops we at first supposed the insects had been imported from England in the roots. Since, however, we have found that the same insect has been in the neighborhood in very small numbers for quite a long term of years. Our crops in British Columbia suffered quite a bit last season, but this year are very nearly a total failure. From the one place, Chilliwack, B. C., containing 278 acres, we do not expect to reap a harvest of more than 600 bales, whereas we should have from 2,500 to 3,000 bales. From the other place, Agassiz, B. C., we do not expect over 250 bales of hops, whereas we should have 2,250 to 2,700 bales. This will give you some idea of the inroads made by the insect and the resultant loss to persons engaged in hop growing when their yards are attacked by these pests. Of course we readily understand that it would be somewhat out of the ordinary for your Department to attack this problem inasmuch as it is out of the United States, but inasmuch as the pests are now so numerous within about 20 miles of the United States boundary and only a short distance from the Washington State hopyards we believe it is well worth your consideration. Just imagine for a moment the loss that would fall to the numerous growers of hops in the States of Washington, Oregon, or California, if this pest should not be held in check, and would migrate to these sections. We have definite knowledge of their already having spread as far as Sumas Junction, which is on the boundary line between the United States and Canada, where they are attacking cabbage, potato, beets, and other root crops, though the damage done here is not nearly as bad as in the hop fields. * * *

A badly damaged hopyard is shown in figure 13.

During 1908 injury from the hop flea-beetle was reported by Mr. W. W. Stockberger, of the Bureau of Plant Industry of this Department. He mentioned the cases already cited and one reported by Mr. Robert Maitland, of Agassiz, B. C., the latter stating that the ravages of this insect would almost destroy the prospect for a crop during the season. Mr. John Wilson, Agassiz, B. C., who complained

of this species in earlier years, reported, under date of July 11, as follows:

> The flea-beetles have been so numerous that they have stripped every portion of the yard this season. I have noticed these last three days that they are all disappearing, but they all disappeared last season about this time and a second brood came about the middle of July.

This "second brood" was probably merely the first-developed generation of the year.

This species has also come under the observation of various other collectors and observers. During 1906 Mr. Frederick Maskew, while working under the writer's direction in southern California, took it generally in many beet fields. Mr. E. G. Titus, while coöperating

FIG. 13.—View of hopyard, showing how completely the hop flea-beetle keeps down the vines. Note occasional vine that grows up. Agassiz, B. C., June 24, 1908. (Original.)

with this Bureau in the investigation of sugar-beet pests, found it abundantly, and many of the locality records given under the heading "distribution," in California, Utah, Idaho, and other States are from specimens collected by him on sugar beet in 1905, 1907, and 1908.

Writing of this species in July, 1908, Mr. I. J. Condit stated that the beetles were then very common in the vicinity of Chino, Cal., on *Chenopodium album* and *C. rurale*.

METHODS OF ATTACK, FOOD HABITS, AND GENERATIONS.

This flea-beetle affects both surfaces of a leaf, gnawing through the skin and devouring the pulp, usually leaving the skin on the opposite side entire; this later becomes discolored, forming yellowish-

brown freckles as the leaf grows and expands, the skin at this point in time becoming torn and frequently showing holes. When the beetle occurs in moderate numbers the leaves (fig. 14) become riddled, as by fine shot, the punctures being most obvious after the plants have made some growth. In its attack on hops it frequently causes the leaves to look like a mass of network or more or less completely strips the vines of leaves, as shown in figures 15 and 16. As is the case with flea-beetles in general, this species does most harm to young plants. When the beetles occur in considerable numbers they are capable of doing great damage in a comparatively short time, completely devouring the young and tender leaves as fast as they come up.

FIG. 14.—Hop leaves, showing work of flea-beetle. (Original.)

Injury is most noticeable on hops, sugar beet, rhubarb, and some other vegetables.

The beetle is a general feeder, the list of its food plants including, among vegetables, rhubarb, beet, cucumber, turnip, radish, cabbage, mustard, and potato. It feeds also on hops, red and white clover, nettle, dock (Rumex), lamb's-quarters (Chenopodium), pigweed and tumbleweed (*Amaranthus retroflexus* and *A. græcians*), hedge mustard, and common wild-growing black mustard. The probabilities are that, as all of these plants are affected by the adult beetles, a considerable proportion of them serves as food for the larvæ. On this head Mr. Quayle has written that the eggs, larvæ, and pupæ were taken at a depth of from three to six inches from the surface of the ground in hop fields and that the larvæ apparently feed on the roots of hop as well as those of other plants growing in the yards. Since it is well known that the beetles occur in other regions where hops do not grow there must be other larval food plants. It would be interesting, and is important, to ascertain exactly what plant, or plants, is the favorite with the larvæ.

Fletcher,[11] in writing of this species, says that in Canada there are two generations a year, the first appearing in June and the second in August. The generation appearing in August is with little doubt the newly developed first generation, and, reasoning from analogy, i. e., from what we know of related flea-beetles, it is this generation of the beetle that hibernates; thus the so-called "first generation" is simply that same generation reappearing the following spring and early summer

FIG. 15.—Work of flea-beetle after vines are grown. (Original.)

As to hibernation, Piper[6] and Doane[8] have recorded that the beetle passes the winter under stones or rubbish, in which respect it resembles practically all other species of American flea-beetles, and that with the first warm days of spring the beetles emerge from their winter quarters and immediately commence feeding voraciously upon their various food plants.

The following account of the life history and habits of the species in the worst affected locality in British Columbia has been kindly furnished by Mr. H. J. Quayle, who has also given an account of remedial experiments which supplement those previously furnished by conversation with Mr. Eder; indeed, without the information supplied by these two gentlemen this article would be quite incomplete. Before transcribing Mr. Quayle's account it may be well to draw from it, according to the statement of Mr. H. Hulbert, Sardis, B. C., that this species made its first appearance as a hop pest in British Columbia in 1894 and that it has been of great importance for five years, or since about 1903. In regard to Mr. Hulbert's statement that the beetles disappear about June 1 and reappear the last of July, it is obvious that during that period the larvæ are maturing, the pupæ are formed, and the beetles of the first, or new, generation appear.

The following account of the life history and habits of this species as it occurs in British Columbia is taken from Mr. Quayle's manuscripts:

LIFE HISTORY AND HABITS.

The adult.—The beetle appears very early in the spring and, according to reports, patiently awaits the coming of its food plant. This early attack of the beetle as the plants are bursting through the ground and before the leaves are fully expanded is one of the things that makes control work difficult. Before the hops appear the beetles are known to attack the nettle, and often completely riddle the leaves. They also attack other plants, and have been seen, and evidence of their work noticed, on potato, mangel, beet, turnip, dock, lamb's-quarters, pigweed, and red as well as white clover. None of these plants is attacked, however, in preference to hops and it is rarely that they are found at this season on anything but hop vines. In one or two cases they were observed in some numbers on potato, at a considerable distance from hop vines. On a small field of hops that was deserted last year on account of this flea-beetle and planted to clover, the leaves of the latter were considerably eaten.

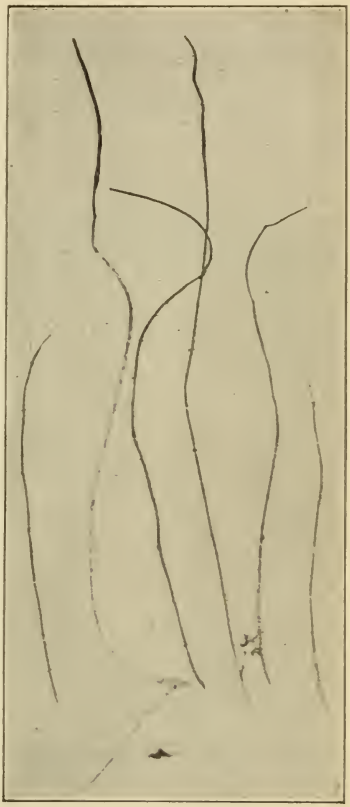


FIG. 16.—Trained hop shoots stripped by flea-beetle. (Original.)

The first appearance of the beetles in this section, according to Mr. Hulbert, was fourteen years ago, and they have been attacking his hops for the past five years. The beetles jump very readily when disturbed, but fall to the ground, usually not far from the base of the vine. Experiments to determine the power of jumping, which is an important factor in control work, indicate that they may not jump more than a foot in the vertical and about a foot and a half in the horizontal.

Feeding occurs almost entirely on the upper surface of the leaves, where they eat out small, nearly round holes about one-eighth of an inch in diameter. This is continued until the leaf is reduced to a network and finally nothing but the main ribs remain. Many of the vines grew to a height of three or four feet, then the foliage was completely stripped off, leaving the dead stalks, which may still be seen in the fields. Many of the vines are thus killed to the ground. Strings were put in place in 1908 in anticipation of the usual crop, but were taken down and saved for another year, as the vines that started afterward were too late to make a crop. Cultivation was stopped and a thousand sheep were imported from California by the Horst Company to feed in their yards.

The beetles, with their more or less cone-shaped bodies, readily make their way through anything into which they can get their heads, and our experi-

mental cages [fig. 17], which were covered with cheese cloth, had to be recovered with calico. They also make their way through the soil with little difficulty. Experiments to determine this point consisted in burying them at different depths, enclosed in tin cylinders. In two days the beetles appeared through 2, 4, and 6 inches of loose soil, but did not appear from these same depths where the soil was made compact by tamping.

The egg.—A few eggs have been taken on the hop roots about 4 inches below the surface. Obviously, these are most difficult to find and can not be detected at all without a magnifier. To more easily obtain the eggs and younger stages, tin cylinders, 8 inches in diameter and 2 feet high, have been sunk to a depth of 8 inches in the ground, some enclosing hop vines and others in the open field. Large numbers of beetles have been liberated in each of these, and they will be taken up with the soil intact in the tins in two, three, and four weeks, and the soil carefully examined for eggs and larvæ. Beetles taken in mating, and enclosed in vials with earth at the bottom, have laid eggs in from eight to ten days.

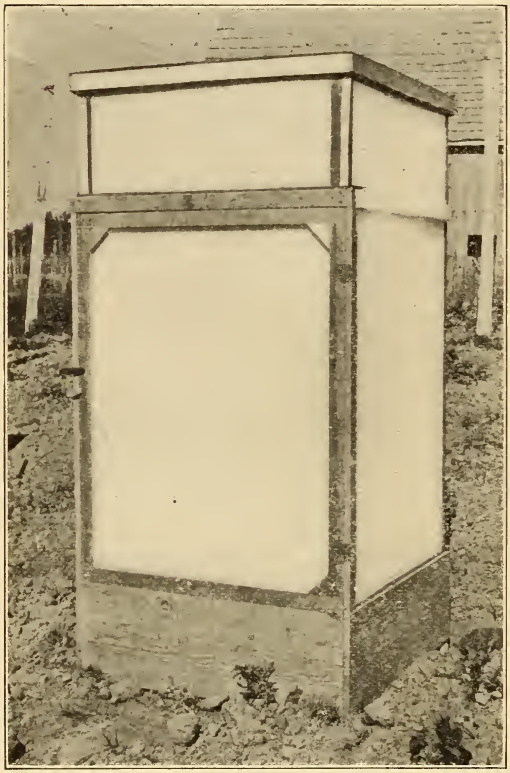


FIG. 17.—Breeding and control cage in place over a hill. (Original.)

The larva.—Larvæ of what the writer believes to be this flea-beetle have been taken from 2 to 4 inches below the surface, both around hop roots and in the spaces between the vines away from any hop roots. While most of the larvæ have been taken about hop vines, I think that they are not restricted, in feeding, to the roots of the hop exclusively, since some have been taken in spaces between the hop vines and also because of the wide distribution of the beetle, both in the United States and in the valleys of the Chilliwack and Agassiz, away from any hopyards. Search about the roots of the nettle and other plants growing along the borders and roadsides failed to reveal any larvæ.

The pupa.—We have also taken pupæ of what was considered this flea-beetle. Transformation to the adult was, of course, necessary to establish this positively and some of the pupæ taken to the laboratory duly transformed. These were taken about the hop roots 3 or 4 inches below the surface.

Both larvæ and pupæ, when sought at the same time, were extremely scarce, and sometimes an hour's search would result in finding nothing. Earlier in the

year would undoubtedly be a more opportune time for getting the younger stages, but our rearing-cage experiments, starting with the beetles in mating, should give us ample material for the study of the younger stages. The scarcity of the larvæ at the time when sought is attributed by the writer to the fact that it was too late for the large numbers of spring and too early for those expected to appear about six weeks later, according to reports of previous years. Those few which were obtained are probably late individuals of the last brood.

Two other kinds of larvæ are taken commonly in the ground, these being wireworms and carabid larvæ. Many of these are very small, just about the size of our flea-beetle larvæ, and the wireworms, when first hatched, are of the same white color, but both of these forms of larvæ can be readily distinguished from the flea-beetle larvæ. The few pupæ obtained are undoubtedly those of what we consider the flea-beetle.

Development.—From all accounts this flea-beetle keeps emerging continuously throughout the season, though there are periods when the beetles occur much more abundantly than at others. Last year Mr. Hulbert stopped using the tarred boards June 1, when practically all of the beetles had disappeared. They did not reappear until the last week in July, when the jarring method was resumed. This year (1908) he continued the use of the tarred boards up to the second week of July, this difference over 1907 being attributed to the cold wet season. According to this, the next lot of beetles may not appear before the last of August of the present year. Beetles have been seen breeding continuously during the past two weeks, though not abundantly, one pair being seen out of seventy-five or one hundred beetles. Beetles are usually present in considerable numbers in the fall, when the hops are mature, and do much direct injury to the product.

NOTES ON OTHER SPECIES.

A few remarks in regard to the larval habits of our other American and some European species of Psylliodes may be interesting. The writer has several times observed the beetles of the equally well-known *Psylliodes convexior* Lec. in numbers on shepherd's purse (*Bursa bursa-pastoris*) in June near the District of Columbia, and it is probable that this is the larval food plant. Until the publication of Mr. Quayle's article [12] there was no record of any of our four species having been reared; hence, the natural conclusion that they were root-feeders. In Europe no less than forty-nine species of Psylliodes are recognized in a recently published catalogue,[a] and the habits of those which have been studied indicate a preference for cruciferous plants, although several are attached to widely different groups of plants. Thus among European species are the hop flea-beetle (*Ps. attenuata* Koch), the potato flea-beetle (*Ps. affinis* Payk.), and a species which is mentioned and figured by Taschenberg[b] as the "raps-erdfloh" (*Ps. chrysocephala* L.). The last is very abundant and has been known for years to attack edible cruciferous crops. It has been recently treated (1906) by Mr. Geo.

[a] Reitter, Catalogus Coleopterorum Europæ, pp. 572–574, 1906.

[b] Praktische Insekten-Kunde, Pt. II, p. 303, fig. 79. Bremen, 1879.

H. Carpenter as a cabbage pest in an article in which the larva is described and illustrated in detail. As to its biology Mr. Carpenter[a] reaches the conclusion that the female beetle lays her eggs on the underground part of the stem and that the young larva burrows through into the interior and feeds in the central tissue of the stem and taproot until mature. The papal stage lasts about three weeks and is passed in an earthen cell just beneath the surface. The natural larval food plant is evidently a wild crucifer.

LOCAL CONDITIONS AND NATURAL INFLUENCES.

Inquiry was made of Mr. Eder during his visit to Washington, D. C., in December, 1908, as to the local conditions in the infested area. From what was learned through him it would appear that the insect's occurrence in such great numbers in the hopyards of British Columbia was due to the equable temperature and to the humidity, which keeps the soil practically always sufficiently moist for the operations of the larvæ feeding beneath the surface.

There can be no doubt, from the writer's observations of our eastern flea-beetles, that these are largely held in check, especially in regions like the District of Columbia, by the extremely dry heat of midsummer. At the time that the flea-beetles are developing as larvæ or undergoing their transformation the ground is nearly baked by the heat during the day and softened only by dews at night. The conditions are very different in British Columbia, and there are, moreover, no other natural causes known which might assist in depleting the numbers of the little pest.

Among natural agencies only a single species of insect has as yet been discovered preying upon this flea-beetle, a hymenopterous parasite which was known to Fitch[2] and which he mentions as a "Chalcidian." It is evidently a species of Perilitus, probably the same species, *schwarzii* Ashm.(?), as has been encountered by the writer on other species of flea-beetles of the genera Epitrix and Phyllotreta. It develops within the body of the adult or beetle. It is not known if this species occurs also in the Pacific region. If not, it might be possible to introduce it.

Fitch's observations and conclusions are interesting, since we have no reason to doubt his theory. Briefly he observed on June 4, 1863, two flea-beetles pairing on a leaf of rhubarb. Presently a parasite alighted near them. It darted upon the back of the female, appearing to be inserting its sting in the tip of her body, whereupon she gave a leap and they both disappeared among the foliage. Fitch conjectured that the "chalcidian" was an egg-parasite of the flea-

[a] Journal of Economic Biology, Vol. I, pp. 152–156, Pl. XI. London, England, November, 1906.

beetle and that the eggs of the latter were so minute that the larval parasite required several of them to nourish and bring it to maturity, as observed of an egg-parasite of the Hessian fly. The parent, watching her opportunity, deposits an egg internally in the ovaries of the flea-beetle, or in the passage-way therefrom, and the parasite larva, taking up its residence there, consumes the eggs of the flea-beetle, one after another, as they develop, whereby none of them will be extruded until after the parasite has attained its growth. In conclusion he writes, "Most singular and truly wonderful as such a provision of nature would be, it is the most probable conclusion I am able to arrive at from past observations."

METHODS OF CONTROL.

Correspondents who have inquired for a direct remedy for use against this species have been advised to experiment with all of the usual flea-beetle remedies. These are, in brief, arsenate of lead. arsenate of lead with resin-fishoil soap, Paris green with and without Bordeaux mixture, Scheele's green, arsenite of lime with soda, dry Paris green with air-slaked lime, Bordeaux mixture alone, and kerosene emulsion. According to Messrs. Eder, Quayle, and others, most of these remedies have been tested more or less completely without being found to be thoroughly effective, owing to the great numbers of the flea-beetles and the rapidity with which the tops of the hop vines grow. All remedies that have been employed have been directed against the beetles only. Unless the hop plants are sprayed nearly every day it is practically impossible to keep them covered with any poison so as to entirely protect them from the ravages of the "fleas." Among other substances tested were tarred boards and sheets, as for leafhoppers. On account of the employment of cheap labor, chiefly Hindu, mechanical and hand methods were found of some value. Snuff was found effective on a small scale and finely powdered tobacco, such as is now on the market as an insecticide, is to be tested.

According to Messrs. Quayle, Eder, and others, the difficulties encountered in the economic treatment of this species are due to two causes: (1) The continual emergence or appearance of the beetles, rendering any method that has yet been employed, such as an arsenical or contact spray, or any mechanical means of capture, such as jarring, of only temporary value, and (2) the extremely rapid growth of the young hop vines, making frequently repeated applications of a spray or other direct remedy a necessity.

ARSENICALS.

Arsenate of lead.—Arsenate of lead, applied at the rate of about 1 pound in from 20 to 50 gallons of water, is advised for use against

the hop flea-beetle. Being more adhesive, this mixture, when sprayed upon the plants, sticks more firmly to the leafage than Paris green, and is also very much less likely to produce scorching or burning; indeed, it has been used at 1 pound to 10 gallons of water on some of the hardier plants, such as potato, without injurious effects. This is, however, not advisable, owing to the extra cost, provided that a weaker solution will accomplish the object. Moreover, scorching is apt to follow its use at this rate on some plants, especially when these are exposed to the direct rays of the sun. The adhesiveness is still further enhanced by the addition of about the same amount by weight of resin-fishoil soap as of the arsenical employed. Mr. Wilson reported that arsenate of lead, applied at the rate of 4 pounds to 40 pounds of Bordeaux mixture, was inadequate, yet Mr. Quayle reports that used at the rate of 5 pounds to 50 gallons it will kill a large number of the beetles, although many take to the new growth that is constantly appearing, or apparently carefully avoid those places on the foliage that have a good coating of poison. The failure of these two arsenicals must be attributed, in large part, to unsuitable spraying apparatus; either of these applications should kill insects on hops, as they have both been found effective, according to Fletcher, against this same beetle on rhubarb in the Northwest Territory and Manitoba.

Dry Paris green.—Mr. Thos. Cunningham reported that very little impression was made by an arsenical spray in the region just mentioned, but stated that Paris green dusted on the plants seemed to produce better results. It was applied by means of a Leggett powder gun. Even then some trouble was experienced; in fact, as the arsenical dust or so-called "dust spray" struck the vines the "fleas" hopped to the ground. "In all my experience with insecticides," he says, "I have never seen anything which will approach the fleas in resistant power."

Paris green spray.—Paris green, being the most readily obtainable insecticide, was advised by this Bureau when information as to remedies was requested. When properly prepared and applied, according to the directions furnished in Farmers' Bulletin No. 127, this insecticide should have no deleterious effect on the hop or other plants affected. It was advised that other food plants growing in the vicinity, such as rhubarb, turnips, and weeds, should be sprayed with the solution.

Regarding its efficiency in hop fields Mr. John Wilson, in a report to the late Doctor Fletcher, stated that when applied at the rate of from 4 to 8 ounces, in combination with Bordeaux mixture, made according to the 4–4–40 formula, or in 40 gallons of water, it was not successful.

SPRAYING APPARATUS USED IN HOPYARDS IN BRITISH COLUMBIA. (ORIGINAL.)

For use against this species in its occurrence on field and garden crops in Washington State, Messrs. Piper and Doane have advised Paris green. The former states that he obtained excellent results by using Paris green liberally but that it is necessary in the treatment of young plants to apply the remedy as soon as attack by the beetles is noticed. Both the wet and the dry methods are advised, as well as the addition of Bordeaux mixture.

Other arsenicals.—Other arsenicals advised in such cases are arsenite of lime with soda,[a] which has the merit of being as effective as Paris green and lime and far cheaper, and Scheele's green, which is similar to Paris green and is employed in the same manner.[b]

SUMMARY ON THE USE OF ARSENICALS.

To sum up the directions for the use of arsenicals, it should be stated that arsenate of lead should take first place because it can be purchased already combined in paste form, and especially because it contains a smaller percentage of free arsenic (60 to 70 per cent), and is therefore less likely to produce scorching or burning; and, moreover, being adhesive, it remains on the plant longer.

Paris green, when combined with lime and water, or with Bordeaux mixture, is almost equally as good as arsenate of lead, and is more readily obtainable in most markets, the ingredients being purchasable practically anywhere. It is quicker in action, but not so adhesive.

The number of sprayings will naturally depend upon the locality and seasonal conditions; possibly it may be necessary to spray every few days when the plants are quite young and the beetles are most abundant. Later there should be longer intervals between sprayings.

Dry mixtures are as a rule not in the same class with the sprays, as they can not be applied so economically, do not so thoroughly cover or adhere so closely to the leafage, and are more apt to cause burning to delicate foliage. Dry Paris green mixed with air-slaked lime in the proportion of about 1 part of Paris green to 10 or 20 of lime is sometimes used, but is less effective, and frequently much of the material is wasted in applying it.

The spraying apparatus used in the hopyards of British Columbia is shown in Plate V and figure 18, the second illustration showing a crew spraying hops through the rows.

CONTACT SPRAYS.

Among the contact sprays tried during 1908 were whale-oil soap, 1 pound of soap to 10 gallons of water; kerosene emulsion, ¼ pound

[a] Prepared in accordance with instructions in Farmers' Bulletin No. 283, p. 37.
[b] Discussed in the publication quoted, as also in Farmers' Bulletin No. 127.

soap and 1 gallon of kerosene to 25 gallons of water; resin, 1 pound to 16 gallons of water; and black leaf tobacco extract, 1 gallon to 65 gallons of water. Of these Mr. Quayle says that the last seemed most effective, with kerosene emulsion next, and that none of these sprays in the given proportion injured the foliage at all.

> It is entirely possible to kill most of the beetles well hit by the spray, but many escape between clods in the soil or are protected by the vine or are concealed in the growing tip. The percentage killed, however, will be satisfactory, but this [treatment] must be repeated so often that the operation becomes laborious and costly.

While kerosene emulsion and whale-oil soap are practically never advised as standard remedies for mandibulate or chewing insects,

FIG. 18.—A crew spraying hops in British Columbia. (Original.)

such as this flea-beetle, both are employed in the infested territory against the hop aphis, or "louse," and therefore the hop grower is familiar with their preparation and use. It has been ascertained that when these are used against the hop aphis the flea-beetles coming into contact with the emulsion are killed. The probabilities are that kerosene emulsion properly prepared and applied in the affected regions will be considerably less expensive than a tobacco extract, and it is possible to make a tobacco extract which would be comparatively cheap. In recent experiments made under the writer's direction at Norfolk, Va., whale-oil soap, used at the rate of about 1 pound to 10 gallons of water, employed against aphides, has proved quite as effective and as economical as kerosene emulsion, considering the fact

that unskilled laborers are likely to make imperfect emulsions and waste the material in applying it. With competent help, and other things being equal, kerosene-soap emulsion should be the more economical spray. It would be well to continue the use of kerosene emulsion at varying rates, including the rate that has been already used and up to 1 pound of soap and 1 gallon of kerosene emulsion to 30 gallons of water. It is possible that if the emulsion were diluted with 10 gallons of water still better results might be obtained, but if labor is cheap the weaker solution, other things being equal, should prove to be the more economical preparation.

BORDEAUX MIXTURE.

Bordeaux mixture, as has been known for years and frequently demonstrated, is a powerful deterrent against flea-beetles and other leaf-beetles, and its use should be continued. Since, as appears to be demonstrated by the observations of Mr. Quayle, this flea-beetle is quite discriminating in taste, it would be well to apply Bordeaux mixture over a considerable surface and use Paris green or arsenate of lead for the remainder of a field, i. e., to spray the majority of the plants in such manner that those which reject the Bordeaux mixture on treated plants would resort to those sprayed with Paris green or arsenate of lead. It should be determined which of these two insecticides has the greater deterrent effect against flea-beetles.

MECHANICAL AND CULTURAL METHODS.

Trap crops.—The great fondness displayed by this species for rhubarb suggests the use of the latter between rows, e. g., in the vicinity of woods, as an attraction or lure for the beetles, it being believed that the beetles will concentrate on these plants and thus give the crops an opportunity to grow to a sufficient height and strength to be able to resist the ravages of the pest. Since certain cruciferous crops are also attacked, such as turnips, it is further suggested that these and other varieties like swedes and rutabagas, rape, and mustard be employed. In the mild climate of the infested region all of these can be grown during the winter, and it seems probable that kale will be found equally effective. Beets, especially mangels, are grown in the affected region and tests should be made with these as trap crops, as also with sugar beet in regions where this crop can be grown profitably.

Rolling the fields.—One of the remedies attempted against this flea-beetle in its occurrence in beet fields, as reported by Doctor Ball, consists in the use of rollers. He reports that "running a corrugated roller over the field as soon as the damage is first discovered seems

to have a very good effect. Just why, is not so clear, possibly because it loosens the ground, breaking up any crust that may have formed, and allows all the beets to get through at one time and in this way some of them get ahead of the beetles. The farmers think it kills the beetles. Cleaning up hedge-banks and rubbish around the fields has been recommended and appears to have had a good effect. It is a lamentable fact that a field that is slightly weedy when the beets appear will not be injured as badly as one that is free from weeds, which probably accounts for the fact that replanted beets are rarely destroyed."

The use of fertilizers.—Where fertilizers are used the plants are undoubtedly aided in recovering from attack by this flea-beatle, but fertilizers are not remedies. Possibly where mineral fertilizers are applied heavily they might have some effect on the larvæ, but it is doubtful if a sufficient amount of an irritant salt would remain in the earth to destroy any large percentage of larvæ at the time when those which have just developed from the egg or have just molted are feeding on the roots. It is worth mentioning, however, that Mr. Theo. Eder noticed that when a fertilizer consisting of 3 per cent nitrogen from nitrate of soda, 12 per cent potassium oxid (K_2O) from muriate (chlorid) of potash, and 9 per cent phosphorus pentoxid (P_2O_5) from superphosphates was applied there were practically no flea-beetles. This fertilizer, however, was considered too expensive, owing to the cheapness of hops in the affected region of British Columbia.

Irrigation.—Irrigation has been suggested and, on the authority of Prof. E. G. Titus, the flea-beetle, when it is working on sugar beets, can be driven away during irrigation by disturbing the beets, thus causing the beetles to jump into the water and be swept away.[a]

Tarred catchers.—Tarred sheets, boards, or similar contrivances on the plan of "hopperettes," in use against leafhoppers, have been employed in the infested region for capturing the flea-beetles. Mr. Hulbert reports having destroyed large numbers by catching them on tarred sheets as they fell from the vines after being disturbed. Mr. Quayle also reports success with a "catcher" which he describes substantially as follows:

> The receptacle used consists of a stout canvas about 3 feet by 4, to which is nailed, on the under side, three strips of boards with one at right angles, to keep the canvas taut. A handle is fastened to two of these strips to project upward and backward, by means of which the apparatus is operated. This is lifted from vine to vine and the beetles jarred off with wisps of hay. Usually two men work together on the same row, the two canvases placed together on each side of the vine.

[a] Bul. 67, Bur. Ent., U. S. Dept. Agr., p. 112, 1907.

HOP FIELDS FROM WHICH TRAINING TWINE WAS REMOVED IN JUNE OR JULY, PHOTOGRAPHED IN AUGUST.

Beetles abated somewhat the last of July and hops began to put out new shoots. Weed growth kept down by sheep pasturage. Hop-leaf growth pastured very close in fall. (Original.)

This method captures a satisfactory percentage of the beetles and should be comparatively inexpensive. But unfortunately the repeated operations which are necessary bring the cost to a high figure. It cost Mr. Hulbert last year approximately $1.25 per acre for each operation. He went over his vines six times, and some parts of the yard eight or ten times. He expected to go over it at least twice more, so that the total cost would be from $10 to $15 per acre.

In figure 19 a portion of a hop field is shown which illustrates the tarred "boards" in place for use. The flea-beetles are dusted off of the vines upon these tarred receptacles with wisps of hay, as

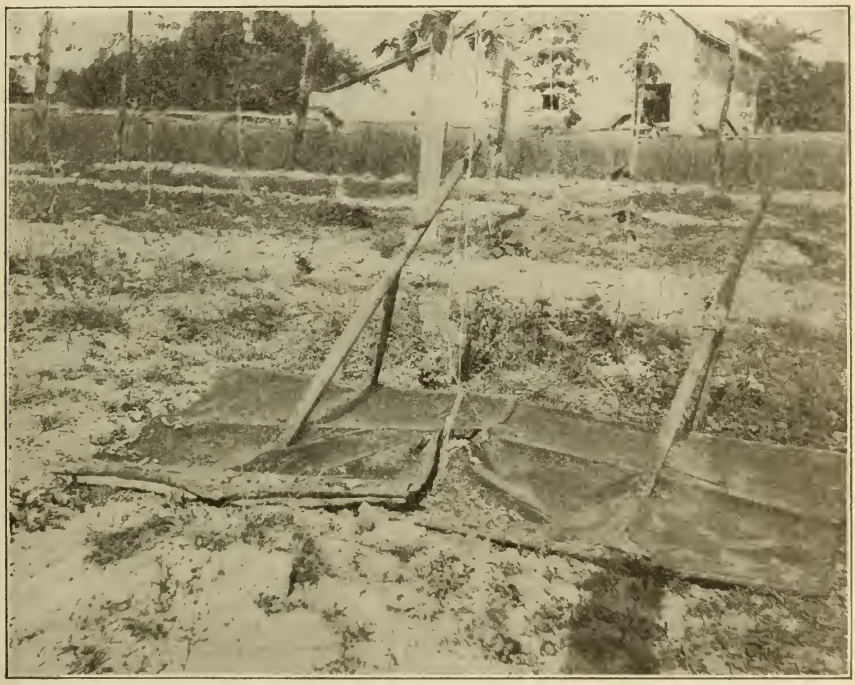


FIG. 19.—Portion of hop field with tarred boards in place. Flea-beetles are dusted with wisps of hay from the vines onto tarred boards. (Original.)

described above. All of the vines were tanglefooted, but the flea-beetles went up the poles and crossed over on the wires overhead until the tanglefoot was applied. Plate VII illustrates the method of capturing the hop flea-beetle on tarred horse sledges, also by shaking the vines. Millions were captured in this way.

CLEAN CULTIVATION.

Frequent stirring of the soil and other cultural operations seem, as yet, to be of no appreciable help, according to Mr. Quayle, and the kind of soil also seems to have little or nothing to do with the abun-

dance of the beetles, which are found in light, sandy, and heavy soils. Mr. Quayle further says:

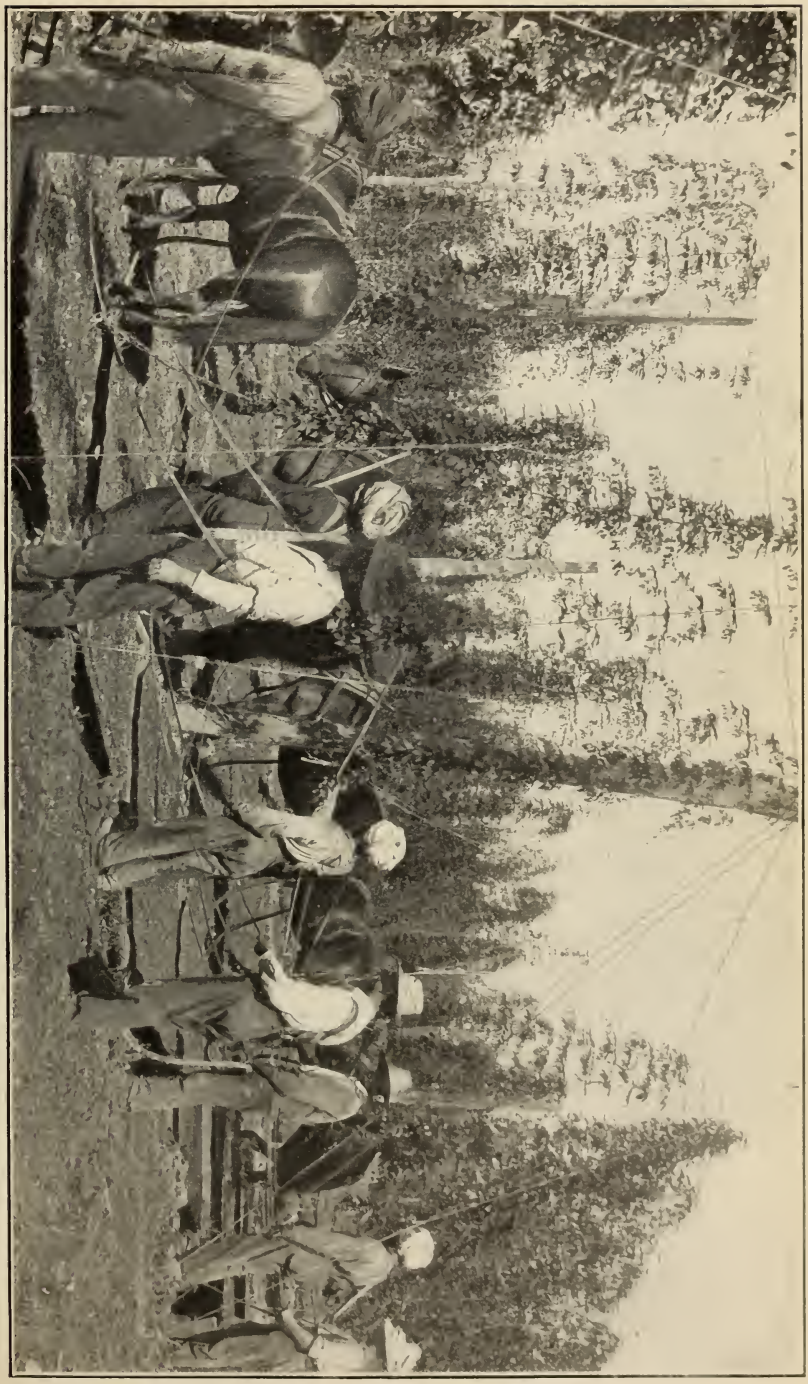
> The control measures which have been tried have been necessarily directed entirely against the adult or beetle, and considering the rapid growth of the vines and the continuous appearance of the beetles no effective and practical remedy has yet appeared. With further work on the younger stages it may be possible to find here a vulnerable point of attack.

One of the most promising remedies for this as well as other insect pests is the employment of clean methods of culture. Since it has been found that the flea-beetles ensconce themselves in any available shelter, such as the cracks in the hop poles, even although these may have no bark remaining, it has been thought desirable to dip the poles in a preparation which will not only close the cracks but which will also repel the pests. Fuel oil, a grade of crude petroleum, is being tried, according to Mr. Eder, since it can be purchased as low as 2 cents a gallon. Tar might serve the same purpose and should act as strongly as a repellent and close the cracks more closely and would not be so disagreeable to handle. The poles are dipped into the boiling fuel oil, but the tar would also have to be heated very hot before dipping.

It is customary to plow thoroughly and to cultivate where possible so as to keep down the weeds, and this method of tillage must, of course, be continued, as the insects find food in weeds of the kind which have been mentioned in the opening paragraph, viz, dock, lamb's-quarters, pigweed, and the like, and also cruciferous weeds. If, by preventing the insects from hibernating in the hop fields in débris, the fields can be practically freed from them, the next step is to prevent their hibernating in near-by timber, as there can be little doubt that in such places are their favorite winter quarters. It is practicable in many cases to cut down small sections of timber in order to accomplish this purpose.

In answer to the question as to the remnants after the hops are picked, Mr. Eder informed the writer that the expedient of cutting the tops and destroying them by burning led to the discovery that the beetles enter into the hollow stalks, remaining in hibernation there in great numbers. With the discovery of this habit he will permit remnants to remain as long as there is any prospect of the insects' trying to obtain winter shelter in them, and then will have all débris burned at about the time of the first frost. One method of destroying field remnants and weeds, by sheep pasturage, is illustrated by Plate VI.

The writer has suggested the addition of burlap wrapped about the poles which have been treated with tar or which do not have an odor strong enough to repel the insect. This will attract the insects for hibernation, and can be removed after the first frost, or there-



METHOD OF CAPTURING HOP FLEA-BEETLES ON TARRED HORSE SLEDGES BY SHAKING THE VINES; MILLIONS CAPTURED IN THIS WAY. (ORIGINAL.)

abouts, and thrown into hot water, and after drying will be available for use in other seasons.

If, with another year's experience, we could ascertain how best to control the insect, either by killing the beetles with arsenate of lead or other arsenical, kerosene emulsion, or whale-oil soap, or by destroying the larvæ in the ground, the problem would be partially solved. One, two, or perhaps even three of these remedies might be used in combination and excellent results obtained. In any case, if we can partially control the insects by any one of them we should not forget that cultural remedies, and especially clean culture, are the most valuable remedies that can possibly be employed against insect pests. Indeed, with many species, if cultural practices were properly followed out, with the cooperation of our neighbors, insecticides would in the course of time, after the balance of nature had been restored, seldom be needed save in case of severe outbreaks, which are likely to occur more or less spasmodically with most of our noxious insects.

LITERATURE.

A complete bibliography of this species is appended and only a brief review of published accounts need be given. The original description of the species appeared in 1847,[1] and it was not until twenty years later that we had any record of the insect's habits. In 1867 Fitch[2] wrote a two-page account regarding injury to cucumber, rhubarb, and radish, furnishing notes on a parasitic natural enemy. In 1884 our first account of injury to hops, a brief one, was written by Dr. J. B. Smith.[4] These accounts were followed by one from Piper[6] on injuries to certain truck crops in Washington State in 1895 and by Doane[8] of similar injuries in 1900. The writer[7] noted the abundance of the species on rhubarb near Washington, D. C., in 1897. Forbes and Hart[9] have given a brief account of the insect from the standpoint of its injuries to sugar beet in Illinois, and Fletcher[10, 11] published two accounts of the species in 1904 and 1907, respectively. In 1908 was published H. J. Quayle's article,[12] in which first mention is made of the larval habits of the insect.

BIBLIOGRAPHY.

1. Melsheimer, F. E.—Proc. Acad. Nat. Sci. Phila., Vol. III, p. 166, 1847.
Original description from Pennsylvania as *Haltica punctulata* n. sp.

2. Fitch, Asa.—11th Rept. Ins. New York, pp. 38–40, 1867.
A 2-page account with mention of food plants and a parasite; observed feeding on cucumber, rhubarb, and radish.

3. Fitch, Asa.—Ill'd Ann. Reg. Rural Affairs, 1867–8–9, Vol. V, p. 204, 1873.
A brief note, with mention of attack on cucumber and melon.

4. Smith, J. B.—Bul. 4, o. s., Div. Ent., U. S. Dept. Agr., p. 50, 1884.
Mere mention of occurrence in hopyards, where the beetles eat small holes in the leaves, doing no great damage.

5. Horn, G. H.—Trans. Amer. Ent. Soc., Vol. XVI, pp. 310, 311, 319, 1889.
Revised technical description, distribution, and systematic bibliography.

6. Piper, C. V.—Bul. 17, Wash. State Agr. Exp. Sta., pp. 55, 56, 1895.
Short general account, with list of food plants. Species stated to be "by far the most destructive flea-beetle in the State" [of Washington].

7. Chittenden, F. H.—Bul. 9, n. s., Div. Ent., U. S. Dept. Agr., p. 22, 1897.
Short note on abundant occurrence on rhubarb near Washington, D. C.

8. Doane, R. W.—Bul. 42, Wash. Agr. Exp. Sta., pp. 11, 12, figs. 2, 3, 1900.
A 2-page general account with two original illustrations.

9. Forbes and Hart.—Bul. 60, Univ. Ill. Agr. Exp. Sta., p. 472, 1900; 21st Rept. State Ent. Ills., p. 124.
A brief account; on sugar beet in Illinois.

10. Fletcher, Jas.—Rept. Entom. and Bot. Canada for 1903 (1904), p. 177.
Mere mention as affecting hops at Sardis, B. C., in noticeable numbers.

11. Fletcher, Jas.—Rept. Entom. and Bot. Canada for 1906 (1907), p. 215.
Account of injuries in the Fraser River Valley, B. C., in 1906, with quotations from John Wilson, Agassiz; Thos. Cunningham, Vancouver; and H. Hulbert, Sardis, B. C., which include experiences with remedies.

12. Quayle, H. J.—Journ. Econ. Ent., Vol. I, p. 325, October, 1908.
A short article, with notes of injury in British Columbia; account of habits, all stages, including the egg, being taken 3 to 6 inches from the surface of the ground, larvæ feeding at the roots of hop and other plants growing in the yards; list of food plants, and difficulties of applying remedies.

SUMMARY.

The hop flea-beetle, a minute, black insect, feeds on various succulent plants. It does serious damage to hops in British Columbia and less injury to sugar beet and vegetable crops in the Pacific coast region.

Its life history is only partially known, but all stages have been found about the roots of hops and the larva probably feeds on most of the same plants as the adult. It is feared that this species may become an important hop-pest in Washington and Oregon, and it doubtless does more injury to beets than is generally accredited to it. Injury is most severe to young plants, but on sugar beet the operations of the beetles throughout the season undoubtedly have a deleterious effect and necessarily decrease the yield.

The abundance of the beetles when they appear early in the season on young plants, their constant reappearance, and the constant new growth of the plants from day to day make it difficult to apply direct remedies with more than temporary benefit. Where the hops are sprayed with kerosene emulsion or whale-oil soap for the hop aphis the numbers of the beetles are lessened. Among measures which give promise of value are the institution of clean methods of cultivation, including deep fall plowing, treating hop poles in such manner as to prevent the beetles from hibernating in them, and clearing all remnants from fields so as to leave them as bare as possible to prevent the beetles from sheltering there in winter. Arsenate of lead, Paris green, kerosene emulsion, whale-oil soap, and Bordeaux mixture should receive further tests, as should the employment of trap crops in the manner advised in this article.

U. S. D. A., Bul. 66, Part VII. Issued July 19, 1909.

SOME INSECTS INJURIOUS TO TRUCK CROPS.

MISCELLANEOUS NOTES ON TRUCK-CROP INSECTS.

By F. H. Chittenden, Sc. D.,

In Charge of Truck Crop and Stored Product Insect Investigations.

SUCCESSFUL USE OF ARSENATE OF LEAD AGAINST THE ASPARAGUS BEETLE.

During the first week of June, 1908, Mr. W. A. Orton reported the common asparagus beetle (*Crioceris asparagi* L.) very injurious at Takoma Park, D. C., and made some experiments with arsenate of lead with complete success. Directions for application, as given in Circular 102 of this Bureau, were followed. The first application was made with 1 pound of arsenate of lead to 20 gallons of water and the second a week later, as the plants had grown rapidly in the meantime and a great many new larvæ had hatched. The second application was made at the rate of 1 pound to 15 gallons of water. The first application destroyed most of the insects, but after a few days a considerable number had developed. These appeared to have been all killed the day after the second spraying. Neither spraying seemed to injure the plants in the least, but the liquid adhered in fine drops to the foliage and was visible there for some time. An unsprayed plat on a neighbor's place was considerably injured by these insects, and up to July 1 no more had appeared on Mr. Orton's crop. He pronounced the treatment very effective. The work was done with a compressed-air machine or autospray.

Mr. Edward A. Eames, Buffalo, N. Y., writing of the value of arsenate of lead as a means of combating the common asparagus

Note.—The accompanying Part VII includes short notes on some of the insects which have been treated in earlier parts of this bulletin and notes on two insects not hitherto recorded as injurious in the United States. To the former class belong notes on the asparagus beetles and the asparagus miner, species considered more in detail in Part I, pages 1–10, and notes on watercress insects in addition to what has been published in Part II, pages 11–20. To the second class belong notes on the injurious occurrence of the pea moth in the United States and a short account of a new western root-maggot.—F. H. C.

beetle, stated that the larvæ of this species threatened to devour his this year's spring-set asparagus to the ground. But after one thorough spraying with arsenate of lead it was difficult to find any but dead larvæ on the plants. Successive sprayings were of course necessary, because the beetles continued to come from neighboring gardens to deposit eggs on the plants and because the developing plants continually presented fresh unsprayed foliage for larval food.

Mr. Eames stated positively that arsenate of lead adhered well, even through several rains, just as its various promoters claimed—a fact which justifies its use in any case even at more initial cost than other poisons which might be used. He also expressed the view that asparagus growers generally should be impressed with the fact that, because of the tendency to spray only once, additional information should be given of the value of extra applications. In conclusion, he stated that he believed arsenate of lead was a specific for this class of insects.

Our correspondent is undoubtedly right. It seems to be as nearly a specific for asparagus beetles as anything that can be obtained, provided it is applied according to directions and that applications are repeated as often as necessary. The trouble is that many truck growers, after spraying a single time, consider that the matter should then be dropped, and if the desired result is not produced, i. e., if the trouble is not wholly stopped, the spraying is condemned or at any rate the insecticide is discontinued, while all that is necessary for the entire season is a second or third application.

A NOTE ON THE ASPARAGUS MINER.

The asparagus miner (*Agromyza simplex* Loew) was reported by Mr. I. J. Condit in the vicinity of Antioch, Cal., August 19, 1908, where the common asparagus beetle was also abundant. The miner was said to be equally numerous and stalks showing infestation were received. The miner-infested stalks could generally be detected by their roughened appearance near the ground.

This species was also taken by Mr. Condit at Oakley and it seems probable, since the common asparagus beetle is found in both localities, that it is becoming generally distributed in California. In one place at Oakley Mr. Condit observed the miner quite common on some stalks, but it did not appear to be equally common over the entire ranch.

During October, 1908, the writer observed this species well established on asparagus in the vicinity of Portsmouth, Va. In October, also, Mr. J. B. Norton reported very severe injury to asparagus in the vicinity of Concord, Mass. The roots of the plants were not only girdled, but the miners worked up the stalks some inches above the ground.

INJURIOUS OCCURRENCE OF THE PEA MOTH IN THE UNITED STATES.

Prominent among the injurious occurrences of the year 1908 was the discovery of the pea moth (*Enarmonia nigricana* Steph.) for the first time in the State of Michigan. August 10 we received from Mr. J. E. W. Tracy, Bureau of Plant Industry, specimens of the larva of this species and its work in growing peas and pods from Charlevoix, Mich.

Mr. Tracy wrote that he obtained the specimens on that day and some days earlier and that Mr. E. W. Coulter and others in that vicinity knew nothing of the identity of this insect, which was causing them considerable concern. The caterpillar first showed itself in very small numbers four or five years before, but it had increased rapidly until the year of writing, when 15 per cent of the peas were ruined. The insect appears to start operations by eating the embryo stem and then moves along the pod until it makes its exit and disappears. Early varieties of peas were the worst sufferers in the affected district. At the time of writing our correspondent found a less number of living larvæ than previously.

This appears to be the first record of the appearance of this insect in the United States, although it has been known as a pest in Canada for several years and has undoubtedly been present in our Northern States, where peas are grown, without having been recognized as anything new or unusual.

A two-page account of this species has been published by the writer in Bulletin No. 33, pages 96–98, which includes a brief illustrated description of the moth and larva and a consideration of the distribution, nomenclature, history, habits, and remedies.

This insect first came to notice near Toronto, Ontario, in 1893, and notices of its ravages in Canada were given in several subsequent years by the late Dr. James Fletcher in his report as entomologist and botanist of the Dominion of Canada. It is an importation from the Old World and is well established in New Brunswick and Nova Scotia as well as in Ontario, and is also recorded from Manitoba.

The name of this species was omitted from the Dyar catalogue of Lepidoptera, but is included in Smith's Check List of Lepidoptera under No. 5702. In most publications the species is mentioned as *Semasia nigricana*.

A NEW WESTERN ROOT MAGGOT.

August 16, 1907, Mr. E. M. Ehrhorn sent from San Francisco, Cal., some radishes, the roots of which were affected by a maggot. The adults were reared September 3 to 20 and were referred to Mr. D. W. Coquillett for identification. They were first mistaken for *Pegomya cepetorum*, because of the very close relation of the two species, but

when more material of both sexes was obtained they were seen to be different. Mr. Coquillett states that some individuals have the bristles practically as in *cepetorum*, but in the males the median black stripe of the abdomen is continuous. This material corresponds so well with Stein's description [a] of *Chortophila planipalpis* as to leave no reasonable doubt of the species. The type locality is Idaho. The insect will therefore be known as *Pegomya planipalpis* Stein, and may be called the western radish maggot. Another lot of the maggot was received from the same source October 1, larvæ and pupæ both being present. From this lot adults issued November 1 to 21.

November 21, 1908, we received from Mr. Charles Heise, Aberdeen, Wash., a section of turnip mined by larvæ which are probably of this species, as also a number of puparia. Our correspondent stated that his observations showed that the maggot works on onions as well as on turnips. As we do not know to the contrary, and do not know positively of the occurrence of any onion maggot in that State, this surmise may be correct. It remains to be verified or disproven. The seed-corn maggot (*Pegomya fusciceps* Zett.) occurs in that region and is more apt to be the onion-feeding species.

Two natural enemies of this radish maggot have come under observation and have been identified by Mr. J. C. Crawford, as follows:

Aphæreta sp.—September 3, 1908, many braconids of a species of the genus *Aphæreta* emerged from material in which this root-maggot was breeding in infested radish from San Francisco, Cal. It is a small species, shining black in color, with dusky wings and yellow legs. In some specimens there are 21 joints to the antennæ on one side and 22 on the other. It is very similar to the type of *muscæ*, but is larger.

Polypeza sp.—This species was reared from its host October 10, 1907, and appears to be undescribed.

NOTES ON WATER-CRESS INSECTS.

The water-cress leaf-beetle.—May 2, 1907, Mr. J. W. Bryan brought to this office from Halltown, W. Va., specimens of the water-cress leaf-beetle (*Phædon æruginosa* Suffr.), present in the beetle and larval forms, the larvæ at that time about half grown. The beetles were beginning to die and a fungus attack was noticed when received. Numerous individuals of the beetle and one larva were parasitized by the fungus. The fungus was tentatively determined by Mr. Haven Metcalf, Bureau of Plant Industry, as *Entomophthora sphærosperma*. If this identification is correct, there can be no doubt that the fungus attacked the insect before death, and may therefore be a factor of value in its natural destruction.

[a] Berl. Ent. Zeitschr., Vol. XLII, pp. 234–235, 1897.

Since the publication of the writer's preliminary articles on the water-cress leaf-beetle and sowbug in the present bulletin (pp. 11–20) it has been noticed that earlier accounts of the related European *Phædon betulæ* L., known as the mustard beetle and "blackjack," were made by Miss E. A. Ormerod, who furnished several references with illustrations in her manual.[a] From this account it appears that injury was first noticed, at least in England, in 1854, to white mustard crops near Ely. Another account of this insect is given in the same author's report for 1886.[b]

The water-cress sowbug.—April 16, 1907, Mr. C. A. Killinger, Shippensburg, Pa., sent specimens of the water-cress sowbug (*Mancasellus brachyurus* Harg.) in different stages, stating that it was destroying his water cress, working on the leaves under water, cutting them close to the stem. If the cress is light or does not grow fast, as happens in winter, they also work on the stems and roots, cutting the plants loose and causing them to float downstream. Our correspondent thought that this species was brought to that section from Virginia.

Experiments conducted with lime in a small spring the previous summer succeeded in killing most of the sowbugs, but plenty of them remained at the time of writing. The lime, however, burned the cress, causing it to turn yellow.

December 23, 1908, Mr. F. W. Houston, a grower and shipper of water cress at Lexington, Va., wrote of this species, inquiring for literature and a remedy. He stated that he had a spring under cultivation that was infested with the water-cress sowbug, and later—March 11, 1909—he sent specimens. In this connection he wrote as follows:

> I have a spring under cultivation which has been infested by them for several years. I fought them for a time by putting the water into ditches and exposing the rest of the cress bed to the sun. In these ditches I would make frequent applications of lime; this, of course, was done during the early summer, after the shipping season closes. It seems to kill all of the sowbugs, but when I put the water into the beds and reset the cress, hauling it from an uninfested spring, it was not long until the "bugs" were again noticed, and in a short time they were as thick as ever.

Mr. Houston was advised that in the case of the old beds the water should be drawn or turned off and that the cress should be completely destroyed and the spring reset with uninfested cress.

---

[a] Manual of Injurious Insects and Methods of Prevention. London, 1890, pp. 151–156.

[b] Report on Injurious Insects for 1886, pp. 59–60.

INDEX.

Page.

Actinotia derupta, bibliographic reference 70
Agallia bigeloviæ on sea-blite (Dondia) 50–51
sugar beet 50–51
cinerea on sugar beet 50–51
novella on sugar beet, habits 51
quadripunctata on sugar beet, habits 51
sanguinolenta on sugar beet 50–51
uhleri on sugar beet 50–51
Agromyza simplex 1–5
biological notes 2–3
descriptive 1–2
distribution 2
historical notes 2–3
injury, recent 3–4
on asparagus in California, Massachusetts, and Virginia 94
remedial measures 4–5
Allygus sp., of Bruner, probably *Eutettix strobi* 49
Amaranth, spiny, food plant of *Prodenia eridania* 53, 58–60, 62, 69
Amaranthus spinosus. (*See* Amaranth, spiny.)
græcians, food plant of *Psylliodes punctulata* 77
retroflexus, food plant of *Psylliodes punctulata* 77
Apateticus (*Eupodisus*) *mucronatus*, enemy of *Prodenia eridania* 64
Aphæreta sp., parasite of *Pegomya planipalpis* 96
Aphiochæta nigriceps eating pupæ of *Prodenia eridania* 63
Apple, food plant of *Cleora pampinaria* 24, 25
Empoasca 51
Army worm, semitropical. (See *Prodenia eridania*.)
Arsenate of lead against common asparagus beetle 8–9, 93–94
cranberry spanworm 26–27
hop flea-beetle 83–85, 87, 92
semitropical army worm 65–69
striped garden caterpillar 32
and Bordeaux mixture against hop flea-beetle 83–84
striped garden caterpillar 32
resin-fishoil soap against hop flea-beetle 83–84
soap against common asparagus beetle 8–9
Arsenite of copper, adhesive, against semitropical army worm 65–69
analysis 69
lime with soda against hop flea-beetle 83, 85
Asclepias incarnata. (*See* Milkweed.)
Asparagus beetle, common. (See *Crioceris asparagi*.)
twelve spotted. (See *Crioceris 12-punctata*.)
beetles, notes on distribution and destructive occurrences 6–10

Page.
Asparagus, food plant of *Agromyza simplex* 1–5
Cleora pampinaria 21, 25
Crioceris asparagi 6–8
12-punctata 9
Mamestra legitima 28–32
miner. (See *Agromyza simplex.*)
Atriplex confertifolia, food plant of *Eutettix clarivida* 50
insana 50
pauperculata 50
tenella 35
food plants of *Eutettix albida* 50
Ball, E. D., paper, The Leafhoppers of the Sugar Beet and their Relation to the "Curly-leaf" Condition 33–52
Beet, food plant of *Eutettix seminuda* 50
Prodenia eridania 61
Psylliodes punctulata 77, 79
leafhopper. (See *Eutettix tenella.*)
sugar, "curly-leaf" condition with relation to *Eutettix tenella* 33–48, 52
leafhoppers 33–52
food plant of *Agallia bigelovix* 50–51
cinerea 50–51
novella 51
quadripunctata 51
sanguinolenta 50–51
uhleri 50–51
Empoasca 51–52
Eutettix clarivida 50
scitula 44–45, 49–50
strobi 44–45, 49
tenella 35
Psylliodes punctulata 71, 74–77, 92
Blackberry, food plant of *Cleora pampinaria* 24, 25
Mamestra legitima 30, 32
"Blackjack." (See *Phædon betulæ.*)
"Blight" of sugar beet, characteristics 44–46
relation to leafhoppers 33–52
or "curly-leaf" of sugar beet around Spreckels, Cal., not work of *Eutettix tenella* 46
"Blue beetle." (See *Phædon armoraciæ.*)
Boards, tarred, against hop flea-beetle 83, 88–89
Boarmia collecta=*Cleora pampinaria* 22
fraudulentaria=*Cleora pampinaria* 22
frugallaria, bibliographic reference 27
=*Cleora pampinaria* 22
pampinaria, bibliographic reference 27
=*Cleora pampinaria* 24
sublunaria, bibliographic reference 27
=*Cleora pampinaria* 22
Bordeaux mixture, deterrent against hop flea-beetle 87, 92
with arsenate of lead against hop flea-beetle 83–84
striped garden caterpillar 32
Paris green against hop flea-beetle 83–85
Bursa bursa-pastoris, food plant of *Psylliodes convexior* 81

Page.
Cabbage, food plant of *Mamestra legitima* 30, 32
Phædon armoraciæ 18
Prodenia eridania 61
ornithogalli 30
Psylliodes punctulata 77
Callitricha verna, food plant of *Phædon armoraciæ* 19
Calosoma sayi, enemy of *Prodenia eridania* 64
Cardamine amara, food plant of *Phædon armoraciæ* 19
"Careless weed." (*See* Amaranth, spiny.)
Carp, suggested use against water-cress sowbug 15
Carrots, food plant of *Prodenia eridania* 61
Castor-oil plant, food plant of *Prodenia eridania* 60
Catfish of no avail against water-cress leaf-beetle 20
suggested use against water-cress sowbug 15
"Chalcidian" parasite of *Psylliodes punctulata* recorded by Fitch 82–83
Chelonus sp., parasite of *Prodenia eridania* 63
Chenopodium album, food plant of *Eutettix strobi* 49
Psylliodes punctulata 76
food plant of *Eutettix scitula* 44–45, 49–50
strobi 44–45
Psylliodes punctulata 77
rurale, food plant of *Psylliodes punctulata* 76
Chittenden, F. H., and Russell, H. M., paper, "The Semitropical Army Worm (*Prodenia eridania* Cram.)" 53–70
paper, "Miscellaneous Notes on Truck-crop Insects" 93–97
"Notes on the Asparagus Beetles" 6–10
"The Asparagus Miner (*Agromyza simplex* Loew)" 1–5
"The Cranberry Spanworm (*Cleora pampinaria* Guen.)" 21–27
"The Hop Flea-beetle (*Psylliodes punctulata* Melsh.)" 71–92
"The Striped Garden Caterpillar (*Mamestra legitima* Grote)" 28–32
"The Water-cress Leaf-Beetle (*Phædon æruginosa* Suffr.)" 16–20
"The Water-cress Sowbug (*Mancasellus brachyurus* Harger)" 11–15
Chlorid of lime, suggested remedy against water-cress sowbug 14
Chortophila planipalpis=Pegomya planipalpis 96
Clean cultivation against hop flea-beetle 89–91, 92
Cleora pampinaria 21–27
bibliography 27
biologic literature 24
descriptive 21–23
distribution 23–24
food plants 25–26
larva, description 22
life history 26
moth, description 21–22
natural enemies 26
pupa, description 23
remedies 26–27
synonyms 22
unpublished office notes 25

Page.
Cleora tinctaria=*Cleora pampinaria* 22
Clover, red, food plant of *Cleora pampinaria* 25
Psylliodes punctulata 77, 79
white, food plant of *Psylliodes punctulata* 77, 79
Cochlearia armoracia, food plant of *Phædon armoraciæ* 19
Collards, food plant of *Mamestra legitima* 30, 32
Prodenia eridania 53, 69
ornithogalli 30
Cotton cutworm. (See *Prodenia ornithogalli*.)
food plant of *Cleora pampinaria* 24–26
Cowpeas, food plant of *Prodenia eridania* 53, 60, 69
Cranberry, food plant of *Cleora pampinaria* 21, 24, 25
spanworm. (See *Cleora pampinaria*.)
Cress, food plant of *Phædon armoraciæ* 18
water. (*See* Water cress.)
Crioceris asparagi 6–9
control with arsenate of lead 93–94
remedies 8–9
12-punctata 9–10
larva, young, description 10
Crucifers, preferred food plants of Psylliodes 81
Cucumber, food plant of *Psylliodes punctulata* 77
Cultural methods against beet leafhopper 48
hop flea-beetle 87–91
"Curly-leaf" of sugar beet around Spreckels, Cal., not work of *Eutettix tenella* 46, 51–52
characteristics 44–46
conclusions 52
relation to *Eutettix tenella* 33–48, 52
leafhoppers 33–52
Cutworm, cotton. (See *Prodenia ornithogalli*.)
Cymatophora pampinaria, bibliographic reference 27
=*Cleora pampinaria* 22
Deromyia ternata, enemy of *Polistes annularis* 64
Dissosteira carolina affected by fungus 31
Dock, food plant of *Psylliodes punctulata* 77, 79
Dondia, food plant of *Agallia bigeloviæ* 51
Eutettix tenella 35
Ducks against water-cress sowbug 14
suggested remedy against water-cress leaf-beetle 20
Dyar, H. G., technical description of the egg and larval stages of *Prodenia eridania* 55–57
Eggplant, food plant of *Prodenia eridania* 53, 62, 69
Empoasca, association with so-called "curly-leaf" of sugar beet at Spreckels, Cal 46, 51–52
on sugar beet, habits, remedy 51–52
Empusa sp., fungous enemy of *Prodenia eridania* 65
Enarmonia nigricana, injurious occurrence in United States 95
Entomophthora sphærosperma, fungous enemy of *Phædon æruginosa* 96
Epitrix, host of *Perilitus schwarzii* (?) 82
Estigmene (*Leucarctia*) *acræa* affected by fungus 31
Eutettix albida on Atriplex 50
clarivida on sugar beet, appearance and habits 50

Page.
Eutettix insana on Atriplex 50
nigridorsum on Helianthus, discoloration and distortion of leaves resulting 44–45
pauperculata on Atriplex 50
scitula on Chenopodium and sugar beet, discoloration and distortion of leaves resulting 44–45
sugar beet, appearance and habits 49–50
seminuda on beet, appearance and habits 50
straminea on Helianthus, discoloration and distortion of leaves resulting 44–45
stricta, bibliographic reference 48
near relative of *Eutettix tenella* 50
strobi, habits 44–46
on Chenopodium and sugar beet, discoloration and distortion of leaves resulting 44–45
sugar beet, appearance and habits 49
tenella, adult, description 35
at Lehi, Utah 36–37, 38–40
Maroni and in the Cache Valley, Utah 38
Monroe, Utah 38
bibliographic references 48
cage experiments, Lehi, Utah 38–40
descriptive 35
distribution 36
economic relations 41–47
summary 47–48
eggs, description 35
food plants 35
in Oregon, Idaho, and California 46–47
life-history studies 36–40
summary 40
nymphs, description 35
relation to "curly-leaf" condition of sugar beet 33–48, 52
remedies, proposed 47–48
Exorista boarmiæ, parasite of *Cleora pampinaria* 26
Fertilizers against hop flea-beetle 88
Fish against water-cress sowbug 14–15
suggested remedy against water-cress leaf-beetle 20
Flea-beetle, hop. (See *Psylliodes punctulata*.)
European. (See *Psylliodes attenuata*.)
potato, European. (See *Psylliodes affinis*.)
punctulated. (See *Psylliodes punctulata*.)
rhubarb. (See *Psylliodes punctulata*.)
small-punctured. (See *Psylliodes punctulata*.)
"Flea," name for *Psylliodes punctulata* in the West 71
Fundulus diaphanus, *F. dispar*, and *F. notatus*, suggested use against water-cress sowbug 15
Fungous disease of *Prodenia eridania* 65
diseases of *Mamestra legitima* 31
enemy of *Phædon æruginosa* 96
Garden caterpillar, striped. (See *Mamestra legitima*.)
Geranium, food plant of *Cleora pampinaria* 24, 25
Goldenrod, food plant of *Mamestra legitima* 30, 32

Page.
Grass, food plant of *Mamestra legitima* 32
Greasewood. (*See* Sarcobatus.)
Guava, food plant of *Cleora pampinaria* 25
Haltica punctulata, bibliographic reference 91
Helianthus, food plant of *Eutettix nigridorsum* 44–45
straminea 44–45
Hickory, food plant of *Cleora pampinaria* 25
Honey locust, food plant of *Cleora pampinaria* 25
Hop flea-beetle. (See *Psylliodes punctulata*.)
European. (See *Psylliodes attenuata*.)
"Hop-flea," name for *Psylliodes punctulata* in the West 71
"Hopper-dozer." (*See* Tar pan.)
"Hopperettes." (*See* Tarred catchers.)
Hop plant, food plant of *Psylliodes punctulata* 71–92
Horseradish, food plant of *Phædon armoraciæ* 19
"Ichneumon," parasite of *Prodenia eridania* 58, 64
Irrigation against beet leafhopper 48
hop flea-beetle 88
as affecting "curly-leaf" condition of sugar beet 41–43
Kerosene emulsion against beet leafhopper 43, 47–48
Empoasca on potatoes 52
hop flea-beetle 85–87, 92
Killifishes, fresh water. (See *Fundulus diaphanus*, *F. dispar*, and *F. notatus*.)
Kohlrabi, food plant of *Phædon armoraciæ* 18
Lamb's-quarters. (*See* Chenopodium.)
Leaf-beetle, water-cress. (See *Phædon æruginosa*.)
Leafhopper, beet. (See *Eutettix tenella*.)
Leafhoppers and their relation to "curly-leaf" condition of sugar beet 33–52
Leucania nigrofascia, bibliographic reference 70
Lime, air-slaked, with Paris green, against hop flea-beetle 83
remedy against water-cress sowbug, burns cress 97
Limnerium sp., parasite of *Prodenia eridania* 63
Locust, Carolina. (See *Dissosteira carolina*.)
Mamestra legitima 28–32
biologic notes 29–31
control methods 32
descriptive 28–29
habits, summary 32
larva, description 28–29
moth, description 28
natural enemies 31
pupa, description 29
Mancasellus brachyurus 11–15
control methods 12–15, 97
descriptive 11–12
injuries and remedies 97
injurious occurrences 12
Mangel, food plant of *Psylliodes punctulata* 79
Mechanical methods against hop flea-beetle 87–89
Meteorus sp., host of *Spilochalcis* spp 63
parasite of *Prodenia eridania* 63
Milkweed, food plant of *Mamestra legitima* 30, 32

Page.
Mustard beetle. (See *Phædon armoraciæ* and *P. betulæ*.)
common black, food plant of *Psylliodes punctulata* 74–75, 77
food plant of *Phædon armoraciæ* 18
Psylliodes punctulata 77
hedge, food plant of *Psylliodes punctulata* 74–75, 77
white, food plant of *Phædon betulæ* 97
Nasturtium officinale. (*See* Water-cress.)
Nettle, food plant of *Psylliodes punctulata* 77, 79
Noctua xylina, bibliographic reference 27
Okra, food plant of *Prodenia eridania* 53, 69
Ophion tityri, parasite of *Prodenia eridania* 63
Orange, food plant of *Cleora pampinaria* 25
Paris green against common asparagus beetle 8
cranberry spanworm 26–27
hop flea-beetle 83–85, 87, 92
semitropical army worm 65–69
striped garden caterpillar 32
and Bordeaux mixture against hop flea-beetle 83–85
flour against water-cress leaf-beetle 19
plaster or air-slaked lime against water-cress leaf-beetle 19
water against water-cress leaf-beetle 19
dry, with air-slaked lime, against hop flea-beetle 84–85
Pea moth. (See *Enarmonia nigricana*.)
Pear, food plant of *Cleora pampinaria* 24, 25
Peas, food plant of *Enarmonia nigricana* 95
Mamestra legitima 28, 30, 32
Prodenia ornithogalli 30
Pegomya planipalpis on radish 95–96
Pepper, food plant of *Prodenia eridania* 53, 69
Perilitus schwarzii (*?*), parasite of Epitrix 82
Phyllotreta 82
Psylliodes punctulata 82
Phædon æruginosa 16–20
beetle, description 16–17
control methods 19–20
descriptive 16–18
egg, description 17
fungous enemy 96
habits 18–19
injurious occurrence 16
larva, description 17
literature 18
Plagiodera viridis a synonym 18
pupa, description 18
armoraciæ, habits 18–19
synonyms 18
betulæ=*Phædon armoraciæ* 18–19
on white mustard 97
cochleariæ Fab., distinct from *Phædon armoraciæ* 18
Phalæna phytolaccæ, bibliographic reference 70
=*Prodenia eridania* 57
Phlepsius irroratus, mistaken determination of *Eutettix strobi* 49
Phyllotreta, host of *Perilitus schwarzii* (*?*) 82
Phytolacca decandra. (*See* Pokeweed.)

Page.

Pigweed. (See also *Amaranthus retroflexus.*)
food plant of *Psylliodes punctulata* ... 79
Plagiodera cochleariæ Panz., Gyll.=*Phædon armoraciæ* ... 18
viridis=*Phædon æruginosa* ... 18
Podisus maculiventris, enemy of *Prodenia eridania* ... 64
Pokeweed, food plant of *Prodenia eridania* ... 53, 58, 61–62, 69
moth, name for *Prodenia eridania* ... 57
Polistes annularis, enemy of *Prodenia eridania* ... 64
Polypeza sp., parasite of *Pegomya planipalpis* ... 96
Pontia rapæ, enemy of *Prodenia eridania* ... 64
Potato flea-beetle, European. (See *Psylliodes affinis.*)
food plant of *Prodenia eridania* ... 53, 58–59, 69
Psylliodes punctulata ... 77, 79
"Pretty cutworm," manuscript name for *Mamestra legitima* ... 30–31
Prodenia eridania ... 53–70
bibliographic list ... 70
control methods ... 65–69
descriptive ... 54–57
distribution ... 57
early records ... 62
egg, description ... 54
fungous disease ... 65
generations ... 62–63
history ... 57
injury to truck crops ... 53–70
larval stages, description ... 55–57
life-cycle periods ... 62–63
literature ... 57–58
moth, description ... 54
natural enemies ... 63–65
origin ... 57
parasites ... 63
predaceous enemies ... 64–65
Prodenia nigrofascia Hulst a synonym ... 54
pupa, description ... 55
summary ... 69
nigrofascia of Hulst=*Prodenia eridania* ... 54
ornithogalli, association with *Mamestra legitima* in damage to garden crops ... 30
phytolaccæ, bibliographic reference ... 70
Psylliodes affinis, the European potato flea-beetle ... 81
attenuata, the European hop flea-beetle ... 81
chrysocephala on edible crucifers in Europe, habits ... 81–82
convexior, comparison with *Psylliodes punctulata* ... 73
on *Bursa bursa-pastoris* ... 81
notes on various species ... 81–82
punctulata ... 71–92
adult, habits ... 79–80
bibliography ... 91–92
control methods ... 83–91
descriptive ... 72–73

Page.
Psylliodes punctulata, development 81
distribution 73
egg 80
food habits 76–77
generations 78
habits 79–81
host of *Perilitus schwarzii* (?) 82
injuries, recent 73–76
larva, habits 80
life history 79–81
literature 91
local conditions affecting abundance 82
methods of attack 76–77
pupa 80–81
summary 92
Quayle, H. J., account of life history and habits of *Psylliodes punctulata* 79–81
Radish, food plant of *Pegomya planipalpis* 95–96
Psylliodes punctulata 77
Rape, food plant of *Mamestra legitima* 30, 32
Prodenia ornithogalli 30
"Raps-erdfloh." (See *Psylliodes chrysocephala*.)
Resin-fishoil soap with arsenate of lead against hop flea-beetle 83–84
striped garden caterpillar 32
soap and arsenate of lead against common asparagus beetle 8–9
wash against hop flea-beetle 86
Rhubarb flea-beetle. (See *Psylliodes punctulata*.)
food plant of *Psylliodes punctulata* 71, 77
Rolling, remedy against beet leafhopper 48
hop flea-beetle 87–88
Root maggot, a new one from the West 95–96
Rose, food plant of Empoasca 51
Rumex. (*See* Dock.)
Russell, H. M., and Chittenden, F. H., paper, "The Semitropical Army Worm (*Prodenia eridania* Cram.)" 53–70
Russian thistle. (*See* Thistle, Russian.)
Ruta-baga, food plant of *Mamestra legitima* 30, 32
Prodenia ornithogalli 30
Salt-marsh caterpillar. (See *Estigmene* [*Leucarctia*] *acræa*.)
Sarcobatus, food plant of *Eutettix tenella* 35
Scheele's green against hop flea-beetle 83–85
Schilbeodes. (*See* Catfish.)
Sea-blite. (*See* Dondia.)
Semasia nigricana=*Enarmonia nigricana* 95
Shad scale. (See *Atriplex confertifolia*.)
Shepherds' purse. (See *Bursa bursa-pastoris*.)
Sheets, tarred, against hop flea-beetle 83, 88–89
Snuff, against hop flea-beetle 83
Solanum, wild, food plant of *Prodenia eridania* 53, 60
Solidago spp. (*See* Goldenrod.)
Sowbug, water-cress. (See *Mancasellus brachyurus*.)
Spanworm, cranberry. (See *Cleora pampinaria*.)

Page.
Spilochalcis spp., parasites of *Meteorus* 63
secondary parasites of *Prodenia eridania* 63
Sporotrichum minimum, fungous enemy of *Mamestra legitima* 31
Starwort, water. (See *Callitricha verna*.)
Stiretrus anchorago, var. *diana*, enemy of *Prodenia eridania* 64
Strawberry, food plant of *Cleora pampinaria* 21, 24, 25
Striped garden caterpillar. (See *Mamestra legitima*.)
Sulphate of copper, suggested remedy against water-cress sowbug 14
Sweet potato, food plant of *Prodenia eridania* 53, 59–62, 69
Tar pan, or tarred wings, against beet leafhopper 48
Tarred catchers against hop flea-beetle 88–89
Thamnotettix tenellus, bibliographic references 48
Thistle, Russian, food plant of *Eutettix tenella* 35
Tobacco extract against hop flea-beetle 86
food plant of *Mamestra legitima* 30, 32
powdered, against hop flea-beetle 83
Tomato, food plant of *Prodenia eridania* 53, 58, 69
Trap crops against hop flea-beetle 87, 92
plants in control of asparagus miner 4–5
Truck-crop insects, miscellaneous notes 93–97
Tumbleweed. (See *Amaranthus graecians*.)
Turnip, food plant of *Mamestra legitima* 30, 32
Prodenia ornithogalli 30
Psylliodes punctulata 77, 79
mined probably by *Pegomya planipalpis* 96
Veronica beccabunga, food plant of *Phædon armoraciæ* 19
Verticillium, fungous enemy of *Dissosteira carolina* 31
Estigmene (*Leucarctia*) *acræa* 31
Mamestra legitima 31
Violet, food plant of *Mamestra legitima* 30, 32
Water-cress, burned by lime used as insecticide against sowbug 97
food plant of *Mancasellus brachyurus* 11–12
Phædon æruginosa 16
armoraciæ 19
insects, notes 96–97
leaf-beetle. (See *Phædon æruginosa*.)
method of growing to avoid damage by sowbug 13–14
sowbug. (See *Mancasellus brachyurus*.)
Whale-oil soap against hop flea-beetle 85–87, 92
Willow, food plant of *Cleora pampinaria* 24, 25
Winthemia quadripustulata, parasite of *Prodenia eridania* 63
Xylomiges phytolaccæ, bibliographic reference 70

O